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The life history of walleye (Sander vitreus) in Honeoye Lake, New York

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The Life History of Walleye (*Sander vitreus*)

In Honeoye Lake, New York.

A Thesis

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ABSTRACT

The natural reproductive potential of adult walleye in Honeoye Lake was not understood prior to this study. Over 8 million walleye fry are stocked into Honeoye annually and are thought to be the only recruitment source to the adult walleye population. The objectives of my study were to: 1) identify seasonal movement patterns of adult walleye, 2) find and describe spawning locations and habitats using radio telemetry and an underwater camera , and 3) document the presence of naturally produced fry and fingerlings. Twenty-three adult walleye were implanted and tracked for 2.5 years. Walleye established relatively small home ranges (24.2-187.8 ha) and tended to move more during the spawning season (149 m/d) compared to the rest of the year (37 m/d). Eight walleye were captured in, entered or re-entered the Honeoye Inlet channel during the 2002 or 2003 spawning seasons. The other implanted walleye remained in the lake during the spawning season, concentrating near their capture and release sites on the southeastern shore, over apparently unsuitable spawning habitat. No walleye eggs were collected in Honeoye Lake or the Honeoye Inlet channel during the study period, nor was a successful natural walleye hatch detected in 2002 or 2003. Implanted walleye exhibited navigational, homing and site fidelity behaviors in Honeoye Lake. Based on this research I make the following recommendations: 1) the Honeoye Inlet channel, Honeoye Inlet Stream and near shore lentic areas should be evaluated for potentially suitable spawning habitat according to the Habitat Suitability Index (HSI), and 2) given the site fidelity of adult walleye, fry stocking should be focused on areas of suitable substrate for spawning.

BIOGRAPHICAL SKETCH

John C. Foust was born in Waverly, New York in 1974 and grew up in the Northern tier of Pennsylvania and Southern tier of New York. He has enjoyed a life of fishing, hunting, camping and backpacking with his family in the southern, western, and Adirondack regions of New York. John received his A.A.S. in Natural Resources Conservation from Finger Lakes Community College (FLCC) in 1997. He then received a B.T. in Fisheries and Aquaculture from SUNY Cobleskill in 1998. It was at these institutions where his interest in fisheries science was developed. While at SUNY Cobleskill, John worked as an assistant hatchery manager at the campus facility rearing various salmonid species. In 1999, John was hired by the Environmental-Conservation Department at FLCC as a Technical Specialist. In 2001, John started his graduate research with walleye in Honeoye Lake. John lives in Stanley, New York with his wife Julie, and continues to work at FLCC.

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INTRODUCTION

Walleye (*Sander vitreus*) are believed to be native to New York, but the watersheds of origin are unknown (Smith 1985; Festa *et al.* 1986). The New York State Department of Environmental Conservation (NYSDEC) has actively managed walleye since the late 1890s. Creel limits and size regulations have been manipulated since the early 1900s to control harvest (Festa *et al.* 1986). With the reconstruction of the Oneida Lake Hatchery in 1992, management efforts now focus on walleye fry and fingerling production for stocking (Festa *et al.* 1986). As a result, walleye are now in all of the major watersheds of New York State (Festa *et al.* 1986), with sport fishing driving walleye management. Successful management requires an understanding of the survival of stocked fry and fingerlings and their subsequent spawning success.

Honeoye Lake (N42°47.00", W77°30.42") is located in the towns of Richmond and Canadice, Ontario County, New York (Figure 1). It is a shallow eutrophic lake (717 ha) with a maximum depth of 9.2 m and a mean depth of 4.9 m (Schaffner and Oglesby 1978). Summer thermal stratification may occur but does not persist due to shallow depths, and dissolved oxygen profiles suggest periodic bottom anoxia (Gilman, 2004, Finger Lakes Community College, Canandaigua, NY, personal communication). The substrate consists mostly of organic silt and a few areas of gravel, cobble or rubble.

The lake has changed physically and biologically during the past 20 years. Early NYSDEC reports indicated low-density macrophyte beds near shore (Chiotti 1980). However, Hammers *et al.* (2001) reported dense macrophyte beds in all near shore areas, and anglers expressed concerns about fishability. Honeoye Lake is primarily a warm water fishery, as evidenced by flourishing black bass (*Micropterus spp.)* populations;

however, anglers mostly pursue yellow perch (*Perca flavescens)* and walleye. Located close to the Rochester and Buffalo metropolitan areas, the lake receives heavy fishing pressure throughout the year (Chiotti 1980; Hammers *et al.* 2001).

Walleye fry have been stocked in Honeoye Lake since the late 1890s, averaging 2.08 million annually from 1947-1969 and 1.91 million biannually during the 1970s (Hammers *et al.* 2001). Creel census reports during the 1970s noted declines in catch rates indicating decreasing numbers of walleye. Estimated adult walleye numbers were below the desired level of 6,000 in 1976 (Chiotti 1980). Walleye fry stocking was increased to 8.67 million per year in 1981 (Hammers *et al.* 2001) after findings of low recruitment by natural and stocked walleye fry to the adult population (Abraham 1983). In conjunction with increased stocking, the creel limit was lowered to 3 fish and the minimum size limit was raised to 18 in (457 mm) to protect potentially first-spawning adults (Chiotti 1980).

In 1983, the estimated number of adult walleye was 11,075 individuals (Abraham 1983). High catch per unit of effort (CPUE) in trap and gill nets in the 1980s and 1990s indicated an increasing adult walleye population to nearly 30,000 (Hammers *et al.* 2001). Catch rates in 1998-1999 were 0.36 walleye/h, the highest ever recorded in Honeoye Lake (Hammers *et al.* 2001). However, growth rates of the sampled walleye were low (Hammers *et al.* 2001), indicating an over-abundant walleye population and depletion of prey fish populations. The walleye size limit was reduced to 15" to alleviate predation on the forage base, and the most recent walleye population estimate was 20,000 (Hammers, NYSDEC, Avon, NY, personal communication).

There is little documentation about the natural reproductive potential of walleye in Honeoye Lake, nor have their spawning locations and home ranges been identified. Chiotti (1980) reported that walleye did not spawn in the Honeoye Inlet channel, a man-made tributary entering the south end (Figure 1). Hammers *et al.* (2001) noted that 5% of the female walleye captured in trap nets set in the lake were either partially or fully spent. This percentage, although small, suggested some egg deposition in lentic areas. Given the uncertainty about natural reproduction and post-stocking survival, studies of the walleye population of Honeoye Lake were recommended (Abraham 1983; Hammers *et al.* 2001).

The goal of this study was to document the natural reproductive potential of walleye in Honeoye Lake in the Finger Lakes region of western New York. The three objectives were to: 1) identify seasonal movement patterns of adult walleye: 2), find and describe spawning locations and habitats using radio telemetry and an underwater camera and: 3), search for the presence of naturally produced walleye fry and fingerlings. To facilitate detection of naturally produced fry, the NYSDEC did not stock walleye fry during the 2002 season. However, Honeoye Lake received 8.7 million walleye fry on 6 May 2003.

Walleye spawning habitat review

Temperature, bottom substrate, and light intensity play important roles in the distribution of walleye in a body of water. Walleye prefer water temperatures of 20-23°C (Ferguson 1958). Originally, walleye were found in large lakes and rivers of moderate fertility (Jovanic 1970; Smith 1985; Colby *et al.* 1979), and they were typically associated with hard substrates such as sand, gravel, rock and shoals. As a result of stocking efforts, however, walleye are now in many habitats, such as eutrophic to oligotrophic lakes, reservoirs, streams, and rivers (Eschmeyer 1950; Jovanic 1970; Festa *et al.* 1986). Adult walleye feed in shallow water during low light intensity (typically at night) and occupy deeper water during the day (Eschmyer 1950; Colby *et al.* 1979).

Walleye move to and congregate on spawning grounds immediately following ice-out as the water warms from 3 to 7°C (Jovanic 1970). Males typically arrive before the highly fecund females (9,000-20,400 eggs/kg); spawning has been documented predominantly at night (Eschmeyer 1950). Adhesive eggs are broadcast over the bottom when temperatures are 3.3-10°C (Eschmeyer 1950; Jovanovic 1970; Wendlandt 1996, 1998, 1999; Lowie *et al.* 2001).

Eschmeyer (1950) summarized the findings of many researchers that described the spawning habitats of walleye: mouths of rivers and creeks (Smith 1892); sandy bars in shallow water (Bean 1903); along the entire shoreline, near shore, on gravel bottom (Evermann and Latimer 1910); shallow bars or "flats" at the edge of deep water (Miles 1915); on sticks and stones in running water at the foot of water falls (Bensley 1915); on sand and gravel in shallow water (Henshall 1919); in lakes (over broken rocks, at the point where waves break) if prevented by weather or other causes from entering streams (Cobb 1923; Adams and Hankinson 1928); in streams or in some cases in sandy shallow bays (Dymond 1926); anywhere near the mouth of streams where depth and other conditions are suitable (Adams and Hankinson 1928); small creeks and rivers or in shallow bays near shore (Bajkov 1930); in streams, on sandy bars in shallow water (Fish 1932); in tributary streams or in their lake (Stoudt 1939); on hard bottoms, usually in moving water (Hinks 1943); up tributary streams in riffles or on gravel reefs in shallow waters of the lake (Eddy and Surber 1947); in a tributary stream, over a stony bottom (Derback 1947); and on gravel shoals and bars in a lake, or gravel bottoms in a stream with a good flow of water (Kingsbury 1948). In sum, walleye have been observed to spawn over most lotic and lentic benthic habitats.

Walleye hatch 15-25 days after spawning, depending on water temperature (Eschmeyer 1950; Jovanovic 1970). Larval walleye are believed to be pelagic, congregating near the surface after hatching and, therefore, are distributed by prevailing winds and water currents (Houde and Forney 1970; Grinstead 1971; Forney 1986). In nature, young walleye (< 3 weeks old) have been found to be positively phototropic until 8 weeks of age, at which time they display negatively phototropic behavior (Bulkowski and Meade 1983). The consensus belief is that young walleye exhibit a progressive migration toward deeper water through their early developmental stages. To the contrary, Forney (1975b) stated that post-larval walleye (8.5-9mm) were found within the upper 3m of the water column in Oneida Lake, NY.

MATERIALS AND METHODS

Adult walleye capture

To test for site fidelity, electrofishing was conducted at night along both the southeast and northwest shores of Honeoye Lake from November 2001 to April 2002. Captured walleye were transported to the New York State Boat Launch (NYSBL) at the southeast end of the lake (Figure 1) for biological data collection and implantation of radio transmitters. A numbered t-bar anchor tag was applied to each fish for external identification in the event of angler or other recovery.

Surgical procedure

Before surgery, transmitters, surgical equipment, and personnel were disinfected with a dilute iodine solution. Radio transmitters were surgically implanted into the abdominal cavity of 23 adult walleye according to the procedures of Hart and Summerfelt (1975), Pitlo (1978), and Wendlandt (1996). Thirteen walleye received surgically implanted radio transmitters in November 2001 to give them time to acclimate before the spring 2002 spawning season. Ten more fish were implanted in 2002 and 2003. Candidates weighed more than 900g (Table 1) to conform to the "2% rule" (Winter 1996). Transmitters were 17 mm wide by 51 mm long and weighed 18 grams. Incisions (3-5 cm) were offset 1-2 cm laterally from the mid-ventral line (at which time the sex of each fish was determined) to aid in suturing and to prevent the transmitter from resting on the incision (Ager 1976, Wendlandt 1996). Wendlandt's (1996) modification of the shielded needle technique (Ross and Kleiner 1982) was utilized to exit the trailing whip antenna from the body cavity posterior to the incision. Closure of the incision followed suturing methods of Wendlandt (1996). Wendlandt (Minnesota Department of Natural Resources, personal communication) recommended the application of an adhesive (Nexaband®) to secure suture knots and prevent lake water from entering the incision. Walleye were placed in a holding tank of aerated water immediately following implantation to recover.

Because females broadcast eggs and leave spawning grounds quickly, while males tend to congregate for extended periods at spawning locations (Priegel 1970), both males and females were implanted with radio transmitters. Walleye were anesthetized in a 10 gal volume of 60 mg/L clove oil (Peake 1998) with aeration. Upon loss of equilibrium, fish were laid dorsal side down in a sterilized PVC surgical trough while an assistant periodically moistened the gill membranes with the anesthetic solution.

Walleye implanted on 13 November 2001 were held overnight for initial observation of survival and transmitter retention before release. Subsequent walleye (captured from November 2001 to June 2003) were released into the lake upon achieving normal swimming behavior in the holding tank. All implanted walleye were released in the southeastern corner of Honeoye Lake at the New York State Boat Launch with the exception of fishes 023* and 702** which were released at the northwest corner of the lake (Table 1) to test for home range fidelity.

Spawning season determination and observations

In order to determine the beginning of the walleye spawning season, a trap net was set in the Honeoye Inlet channel immediately following ice-out on 28 March 2002 and 2003. The net was emptied daily to assess walleye spawning run intensity and duration. It was assumed that initiation of walleye spawning in the Honeoye Inlet channel would coincide with potential walleye spawning in Honeoye Lake. To further assess walleye spawning activities, visual observations were conducted at night using a spotlight to detect the "eye shine" of the walleye *tapetum lucidum* at the Honeoye Inlet channel and along the lakeshore.

Locating walleye

A model 2144 Advanced Telemetry Systems (ATS) Inc. scanning receiver (52-54 MHz range) was used to receive signals from F1840 series transmitters operating in the 53.00-53.999 MHz range. Signal pulse rate was 35 per minute, giving the transmitters an expected battery life of 1150 days. The small surface area and shallow depth of Honeoye

Lake allowed for the extensive use of a hand-held unidirectional loop antenna to detect signals.

Tracking began in December of 2001 and continued through August 2003, except during periods of ice cover from January to early March. Tracking was done two to four times per week during the 2002 and 2003 spawning seasons and bi-weekly in non-spawning months.

The goal of each tracking episode was to locate all implanted fish at least once. Tracking episodes began primarily at the NYSBL, traveling north by boat until the first signal was detected. When a signal was detected the general direction of the fish was determined by manipulating the loop antenna to determine the null signal direction. The direction of the null signal was followed until a strong signal was detected at a low gain setting. Fish location was defined where signal strength was strong and unwavering regardless of antenna direction. This method was validated on the night of 21 November 2002 by achieving visual observation of walleye 140 with a hand-held spotlight approximately two meters from the point determined to be its exact location. A tracking episode ended when the entire lake surface had been covered or all tagged walleye were found.

Fish location analysis

Telemetry data was separated into two seasons: non-spawning and spawning. Locations of fifteen implanted walleye were analyzed for potential spawning areas. Fish locations were stored as waypoints with a Garmin *e*-trex® hand-held Global Positioning System (GPS) and downloaded into DeLorme TOPO USA® version 2.0 mapping software. GPS locations were also entered into an Arcmap 9.0 geographic information system (GIS) database for creation of walleye location maps.

Data recorded for each fish location included date, time, fish ID#, water depth, high and low water temperature, high and low DO, latitude and longitude decimal degree coordinates, Secchi depth, distance to shore, and substrate composition. Water depth was measured with an Eagle EZ 2T sonar unit. Temperature and DO from surface to bottom were measured with an YSI® model 85 unit. Distance to shore was calculated using a Bushnell® Laser Rangefinder model 1000. Substrate composition was assigned a categorical score (1= muck, 2= sand, 3= gravel, 4= cobble, 5= boulder) determined by visual inspection of the lake bottom with an Aquaview® underwater video system. Substrate composition at spawning season locations was used to create a map of potential spawning areas.

Individual fish locations were analyzed with the California Home Range Analysis Program (CALHOME in Kie *et al.* 1994). CALHOME calculates a home range for each walleye as a 95% Minimal Convex Polygon (MCP) through an iterative process of eliminating points from the border of a polygon created by all location points until 95% of the original points remain. The program created an OUTPUT file of X, and Y coordinates of the home range outline which was entered into Arcmap 9.0 for plotting. CALHOME typically calculated one polygon per individual fish. However, CALHOME does not distinguish between the lakeshore and surrounding terrestrial environments, so all polygons were clipped to conform to the shoreline of Honeoye Lake. Home range area (ha) was calculated from the clipped polygons by Arcmap 9.0. Except for lotic spawning fish in the Honeoye Inlet channel, both a non-spawning and spawning season

95% MCP was calculated for each fish to delineate core areas of fish activity in Honeoye Lake.

CALHOME was also used to calculate straight-line distance between successive fish locations. Average Daily Movements (ADM in m/d) of implanted fish were calculated by dividing the total straight-line distance traveled (m) by the number of days that elapsed between successive locations.

Temperature data were used to compare ADMs during the spawning (<10°C) and non-spawning (>10°C) seasons (paired T-test). Depths for spawning and non-spawning seasons, averaged for individual walleye locations, were analyzed with a paired T-test.

Walleye egg and larvae sampling

To dredge for walleye eggs, a long handled dip net was used to collect substrate from potential spawning areas in the Honeoye Inlet channel on 30 March 2003 and along the southeast shore of the lake on 1 April 2003. Also, a 0.5 m plankton net (560*u*m) was anchored in the Honeoye Inlet channel for a 24 h period beginning on 1 April 2003 to capture drifting eggs. However, stream flow was inadequate to move the flow meter, rendering the sampling volume unquantifiable.

Sampling occurred on four days each in April and May of 2002 and 2003, with the number of sampling sites increased from 27 in 2002 to 38 in 2003. The 2003 sampling also included one post-stocking sampling date (8 May).

Larval walleye densities in the lake were calculated from the catch in a 0.5 m plankton net (560 *u*m) equipped with a General Oceanics Inc.® mechanical flow meter. The sample net was towed from a boom attached to the gunwale of the research vessel at various depths for 7.5 minutes at 3.2 km/h, for an average length of 333 meters per sample. Sample gear running depths were calculated by method of (Lind 1985). Individual samples were rinsed into a labeled jar and preserved with Ward's Safe ® preservative. A dissecting microscope was used to identify all larval fish. Estimating population sizes of larval fish were determined by following methods set forth by Forney (1984). All fry samples were collected during daylight hours to take advantage of the positive phototropic behavior of the larval walleye (Bulkowski and Meade 1983).

RESULTS

Surgical implantation and harvest

Movements from release sites by all tagged fish confirmed initial survival. Of the 23 tagged fish, only 15 provided substantial data. Anglers caught seven fish (30%, Table 1). Harvested transmitters were re-implanted to maintain a sample size of 20, but one was never relocated after the second re-implantation. Even with intense angler pressure on the study population, nine of the walleye originally implanted in 2001 provided data throughout the 2½ year study.

Spawning season

Duration

Walleye occupied the Honeoye Inlet channel for 14 d in 2002 (28 March to 10 April) and for 21 days in 2003 (28 March to 17 April, Figure 2). Catch rates in the Honeoye Inlet channel trap net were much higher in 2003, averaging 67 walleye/d, compared to 3/d in 2002. Initial temperatures during the presumed spawning run were 5.3°C and 8.3°C in 2002 and 2003, respectively. No walleye was caught in the Honeoye

Inlet channel after temperatures exceeded 13.7°C and 7.7°C in 2002 and 2003, respectively.

Movements and locations

Lotic spawning (presumed)—Eight walleye (transmitter #'s 023, 061, 122, 221, 238, 400, 651, 702*) were captured in, entered or re-entered the Honeoye Inlet channel during the 2002 or 2003 spawning seasons (Figure 3). Four of these fish (transmitter #'s 023, 238, 400, 702*) were captured on 2 April 2002, implanted, and released on 3 April (Table 1) at the NYSBL (Figure 1). Two (023, 702*) returned to Honeoye Lake and were subsequently harvested, while the other two (238, 400), although surviving, did not return to the Honeoye Inlet channel in 2002 or 2003 (Appendix I.1, 2).

Fish 061 moved into the Honeoye Inlet channel in 2002 and 2003, ranging farther upstream in 2003 (Appendix I.3). During 2002, fish 061 entered the Honeoye Inlet channel on 19 March, while the lake was still partially covered with ice, and was found in the lake again on 28 March. Fish 122 briefly entered the Honeoye Inlet channel on 1 April 2003 and returned to the lake by 3 April 2003 (Appendix I.4). Although tagged in the fall of 2002, fish 221 did not enter the Honeoye Inlet channel until the 2003 spawning season, traveling beyond the Finger Lakes Community College Muller Conservation Field Station (FLCC MCFS) on 30 March and returning to the lake by 3 April (Appendix I.5). Among the fish observed in the Honeoye Inlet channel, fish 651 traveled the farthest upstream to near the culvert pipe where the Honeoye Inlet channel diverges from the original Honeoye Inlet stream bed (Appendix I.6). It is believed 651 expired at this location; however, neither the carcass nor transmitter was recovered.

Lentic spawning (presumed)—Eight fish (transmitter #'s 081, 100, 140, 302, 322, 341, 501, 980) did not enter the Honeoye Inlet channel during the periods in 2002 and 2003 when the fish that had entered the Honeoye Inlet channel were presumed to be spawning. The majority of fish not in the Honeoye Inlet channel during the presumed spawning periods were located along the southeastern shore of the lake in close proximity to points of land or intermittent tributaries (Figure 4).

In the lake, individual fish exhibited varying movement behaviors during the presumed spawning seasons, ranging from "roaming" to "inactive." Fish 100 moved widely throughout the lake during the presumed spawning periods in 2002 and 2003 (Appendix II.1). Fish 341 and 501 concentrated north of the NYSBL except during the 2002 spawning season when both individuals completed round trip excursions to an area north of Log Cabin Point (Appendix II.2, 3). Fish 140 also made an excursion during the presumed spawning season, but instead traveled to the southwestern corner of the lake (Appendix II.4). Fish 322 moved north and south along the east shore before the 2002 spawning season, finally occupying an area ~ 2 km north of the NYSBL (Appendix II.5). Fish 980 occupied an area south of Willow Beach for the 2002 spawning season and appeared to "roam" along the eastern shore during the 2003 season (Appendix II.6). Spawning movements for fish 081 and 302 were not apparent; they did not venture far from their release points during the presumed spawning seasons (Appendix II.7, 8).

Core area analysis

Spawning movements were difficult to detect unless sudden excursions of significant distance were observed or a fish occupied a distinct area during the presumed spawning season over the course of several tracking locations. In some cases, distinct areas occupied by individual walleye during the presumed spawning seasons could not be separated by the CALHOME software from home ranges they occupied during the rest of the study. However, spawning and non-spawning season polygons were distinct for some fish. For example, spawning locations of fish 322 produced two separate polygons with one (2002) distinctly different from the non-spawning season home range polygon (Figure 5). Conversely, the roaming behavior of fish 100 inflated the size of the spawning season polygon (608 ha) to encompass the entire home range polygon (Figure 6 and Appendix II.1). The inflated spawning polygon of fish 100 was omitted from the analysis of the spawning season polygons. With the exception of fish 501 (Appendix III.1), the remaining lentic spawning fish (302, 341, 980) had spawning area polygons entirely contained within their home ranges (Appendix III.2, 3, 4). Spawning season core area polygons averaged 57.9 ha and ranged from 0.9 to 118.4 ha (Table 2).

Movement rates, depths, and substrate composition

Walleye moved significantly more during the spawning (149 m/d) than during the non-spawning (37 m/d) seasons ($p = 0.02$) (Table 2, Figure 7). Average water depth of walleye located during the spawning and non-spawning seasons was 2.8 m and 2.5 m, respectively, and did not significantly differ ($p = 0.41$). Benthic substrates at spawning season locations of walleye were predominantly organic silt along with a few suitable habitats along the southeast shore (Figure 4).

Non-spawning season

Movements and locations

The majority of implanted fish exhibited an affinity for the southeastern shore from Burns Point to the south end of the lake (Figure 8), but most were also captured and released there. To test the hypothesis of site fidelity, five fish (023*, 081*, 181, 251, 702**; Table 1) were captured at the northwestern corner of the lake, just south of Sandy Bottom Park (Figure 9), in April and June of 2003. Fish 023* and 702** were implanted and released at the capture area on 29 April 2003 (control). On 16 June 2003, fish 081*, 181 and 251 were released in the southeastern corner of the lake at the NYSBL.

Tracking was conducted on 2 July 2003. Fish 023* was slightly north of its release site (Figure 9). Fish 702** was never relocated, probably due to transmitter failure or unreported capture. Fish 081* and 181 were located close to each other on the western side of the lake south of California Point, and fish 251 had returned to the capture area and was found very near fish 023* (Figure 9). In sum, most of the walleye captured at the northwestern end of the lake remained there or returned to the western side after displacement to the southeastern side of the lake.

Core area analysis

Home range polygons of non-spawning season locations for individual fish exhibited significant overlap (Figure 10). Except for fish 100, all non-spawning season core areas were in the southern third of the lake (Figure 10), but again, all of the walleye for which home range polygons could be calculated were captured and released in this area. Non-spawning season core area polygons averaged 67.9 ha and ranged from 24.2 to 187.8 ha (Table 2). Although not significant ($p = 0.263$), females in Honeoye Lake had larger home ranges on average (111.4 ha) than males (28.7 ha). CALHOME typically calculated one non-spawning season polygon per fish, except for fish 100 that had three home range polygons (Figure 6). However, two of the three home ranges for fish 100 were determined from single points and were treated as outliers (Appendix II.1).

Diel temperatures and movements

Implanted walleye moved significantly more when the water temperature was less than 10°C (<10°C = 77 m/d, >10°C = 22 m/d; $p = 0.01$). On 23 July 2002 (25.4 °C) all fish were located three successive times beginning from near sundown (2125 h) until 0200 h on 24 July. The short time interval between successive locations allowed more precise determination of movement distances (mean = 1.65 m/min). Analysis of fish depth suggested a trend towards slightly deeper water with a return to shallower water over the course of a few hours (Figure 11). However, this trend was not statistically significant ($p > 0.10$).

Egg and fry production

No walleye eggs were collected in Honeoye Lake or the Honeoye Inlet channel during the study period, nor was a successful natural walleye hatch detected in 2002 or 2003. Larval walleye were captured in only one of 65 samples, on 8 May 2003 following the stocking of 8.7 million walleye fry on 6 May. The 8 May walleye fry population in Honeoye Lake was estimated to be 174,000, significantly fewer than the number stocked (Table 3). Sampling tows produced large by-catches of yellow perch and the zooplankter *Daphnia pulex*. Pelagic yellow perch larvae were already present on 29 April 2002 and increased in number through 8 May 2002; however, yellow perch did not appear to hatch until 4 May during the 2003 season (Table 3).

DISCUSSION

Conditions for, and success of, walleye reproduction

Spawning season durations, temperatures and depths

Walleye were in the Honeoye Inlet channel on the first date of trap netting in 2002 and 2003, immediately after ice-out, but the number of walleye caught in the inlet channel was much lower in 2002 (~5/d) than in 2003 (~67/d). Radio tagged walleye were among hundreds of other walleye that entered the Honeoye Inlet channel during this time of year and were assumed to be part of a spawning run. Walleye presence in the Honeoye Inlet channel during the presumed 2002 and 2003 spawning seasons was longer, 14 and 21 days, respectively, than in other spawning tributaries of North American lake systems near the same latitude (Colby *et al.* 1979). It is possible that the 2002 spawning run actually began earlier. Fish 061 entered the channel on 19 March 2002 while the south end of the lake was still covered with ice. However, due to intermittent ice in the channel, the trap net was not set until complete ice-out on 28 March. This situation may explain why the presumed spawning season was 7 d shorter in 2002 than in 2003.

Walleye spawning duration may be influenced by water temperature. Spawning has been reported to begin between 5.6 and 11.1 °C (Priegel 1970; Scott and Crossman 1973; Colby *et al.* 1979) and to end between 9 and 17.2 °C (Niemuth *et al.* 1962; Priegel 1970; Grinstead 1971; Lowie *et al.* 2001). In 2002, walleye were first observed in the Honeoye Inlet channel at 5.2 °C; the last walleye was caught in the channel on 10 April when the water temperature was 13.7 °C (Figure 2). In 2003, walleye were first caught in the inlet channel when the temperature was 8.3 °C; however, the water temperature was

$7.7^{o}C$ when the last significant numbers of walleye were caught in the trap net on 12 April (Figure 2).

Water temperature fluctuations in the Honeoye Inlet channel may have prolonged the presumed spawning runs in both seasons. Wendlandt (1996) reported a similar situation in Lake Minnewaska where the spawning season lasted three weeks. In retrospect, employing a temperature-logging unit would have been useful to analyze the influence of water temperature on spawning run initiation, intensity and duration.

Presumed spawning season depth averaged 2.8 m for implanted walleye within the Honeoye Lake system during the 2002 and 2003 seasons. However, depths recorded may not have represented actual spawning depths because the spawning status of the fish was unknown when they were located by telemetry. Walleye are known to spawn in relatively shallow water ranging from less than one meter to several meters (Colby *et al.* 1979)

Spawning season substrates

During the spawning season, radio tagged walleye were located only rarely at the limited suitable spawning substrates in the lake. Female walleye deposit eggs over a variety of substrates (Eschmeyer 1950), but hatching success depends on substrate quality. Optimal spawning habitat is gravel to cobble in lotic or lentic areas with enough water movement to ensure both adequate oxygenation and minimal siltation; walleye are believed to seek out these substrates during the spawning season (Colby *et al.* 1979). The only suitable spawning habitats in Honeoye Lake that could be identified by radio telemetry locations followed by underwater video were confined to a few areas along the southeastern shore (Figure 4). During the presumed spawning season (late March to mid

April), most implanted walleye in the lake and the four in the Honeoye Inlet channel were located over muddy, organic substrate (Figure 3). The channel is a slow moving, shallow stream with a substrate considered unsuitable for walleye spawning (Hammers *et al.* 2001).

Because the spawning status of a fish when it was located was unknown, the telemetry and underwater camera data showed potential, not actual spawning areas in the lake. Implanted fish located over unsuitable habitat may have moved to more favorable locations to spawn between location events. Also, with the exception of fish 100 and 322 (Figures 5, 6), walleye in the lake during the spawning season did not venture from their non-spawning home ranges. Relative inactivity during the spawning season suggests that either home ranges occupied by implanted fish may have contained suitable habitat for spawning, that some fish did not spawn, or that fish spawned in unsuitable areas.

Finding implanted fish predominantly over organic substrates during the spawning season was not surprising considering the eutrophic nature of Honeoye Lake. However, two major points, Log Cabin and California (Figure 1), have gravel deposits in the near-shore areas adjacent to tributary mouths. The NYSDEC periodically sets trap nets at these locations to assess walleye spawning status (Hammers *et al.* 2001), and many have been captured. My telemetry data did not identify these sites as walleye spawning locations, but no fish were collected or released in these areas. The majority of the implanted fish did not venture far from their areas of capture along the southeastern shore of the lake (Figures 4, 8, 10). It appears that walleye captured and released at the southeastern corner of the lake did not move far enough out of their already established, relatively small home ranges to encounter potentially suitable habitat elsewhere. The suggestion of generally small, restricted home ranges for walleye in Honeoye Lake was supported by the behavior of the four fish captured on the northwestern side of the lake. Two fish released near their capture locations remained nearby and two fish displaced to the southeastern corner of the lake returned to the west side within a few weeks. Thus, even if suitable spawning habitat is available in Honeoye Lake many walleye may never find it due to their restricted home ranges (Pitlo 1978; Einhouse and Winter 1981; Prophet *et al.* 1989).

Spawning success and fry production

With little evidence of adult walleye spawning on suitable substrate, the odds of finding naturally produced larvae were very low, and none were found. Failure to find larvae was not due to inadequate sampling effort or timing. A total of 4,052 m^3 of water was filtered, more than three times the volume sampled by Forney (1984), who also reported no walleye captured before stocking of hatchery fry. Walleye are believed to hatch ten days prior to yellow perch in New York lakes (Forney, Cornell University, personal communication), and many yellow perch fry were captured in my tows (Table 3). If walleye fry were present they should have been captured also.

Even after 8.7×10^6 walleye fry were stocked on 6 May 2003, only five fry were captured on 8 May from a total of 17 samples (Table 3). The density of post-stocking walleye on 8 May 2003 (0.0006 m^3) was much lower than the density (0.037-0.340 m^3) reported by Forney (1984). Walleye fry densities are typically greater in water bodies during years when supplemental fry stockings are conducted (Forney 1975a; Forney 1986; Mitzner 1992).

The surprisingly low number of post-stocking walleye fry captured may have been due to poor distribution from the stocking site in only 2 d or poor survival through inter-or intra-specific competition for food.. Filter feeding zebra mussels (*Dreissena polymorpha*) may be removing smaller zooplankton from Honeoye Lake leaving the larger *Daphnia pulex*, which may be difficult for the "first feeding" walleye fry (i.e. mouth gape and width of 1.5 mm and 0.7 mm, respectively, Li and Mathias 1982) to consume. Other possibilities include, cannibalism (Summerfelt 1996), patchy distribution caused by wind or currents (Houde and Forney 1970), or the sampling areas and depths I chose haphazardly. I sampled near the stocking site (California Point) and far enough offshore, at an average depth of 3.3 m, to avoid gear damage, whereas Forney (1984) used a random grid sampling design to sample at depths above and below the average depth of the lake, but < 6 m.

Walleye movements and locations

Spawning season

The four walleye that entered the Honeoye Inlet channel (Figure 3) were assumed to have attempted to spawn because it was the only time they were found there. In the lake, walleye moved more during the presumed spawning season (149 m/d) that at other times of the year (37 m/d). They may have been seeking suitable spawning habitat, although other explanations cannot be ruled out. Increased walleye movement during the spring was also reported from Lake Bemidji; however, foraging was believed to be responsible (Holt *et al.* 1977).

Home ranges of walleye calculated from non-spawning season locations (Figure 10) indicated that most walleye, excluding the lotic spawning fish, did not leave their home ranges during the spawning season. Only fish 322 established a separate home range during the presumed 2002 spawning season but did not do so in 2003 (Figure 5). Fish 140, 341 and 501 (Appendix II) made brief excursions during the presumed spawning season to new areas in the lake. CALHOME treated the excursions of these fish as outliers in the 95% MCP home range calculations, suggesting a possibility of a spawning movement followed by a rapid return to the home range. Because walleye spawn primarily at night (Eschmeyer 1950; Colby *et al.* 1979), it is possible that tracking them during daylight hours (e.g. 8am-4pm) missed spawning movements or congregations at night. However, Lowie *et al.* (2001) reported that most walleye spawning in Dewittville Creek, a tributary of Chautauqua Lake, NY, took place during daylight hours.

Non-spawning season

Walleye are known to establish home ranges (Pitlo 1978; Einhouse and Winter 1981; Prophet *et al.* 1989). Seven of the implanted fish (4 females, 3 males) established home ranges varying in size from 21.4 to 187.8 ha. Small sample size ($n = 7$) probably accounts for the insignificance ($p = 0.263$) between the average home range size of females (111.4 ha) and males (28.7 ha). However, gender aside, home range size for walleye in Honeoye Lake (717 ha) averaged 85.1 ha, findings consistent with the 10-90 ha home ranges reported for walleye in the much larger Marion Reservoir, Kansas (2511 ha) by Prophet *et al.* (1989). However, variability in home ranges of implanted walleye in Chautauqua Lake (5324 ha) were much larger (37-3500 ha) (Einhouse and Winter 1981).

Non-spawning season locations were concentrated along the southeastern shore of Honeoye Lake very near the initial capture and release sites, for the majority of the walleye. This result suggests that walleye were captured and released in their home ranges, and that they stayed there after tagging. This contention is supported by the precision with which fish 251 returned to its capture site on the northwestern end of lake, after being released at the New York State Boat Launch (NYSBL), which suggested navigational ability and homing. It has been suggested that walleye possess a homing mechanism that allows them to return to previous spawning grounds (Olson and Scidmore 1962; Priegel 1970; Wendlandt 1999), although this ability is less programmed and precise than the one found in salmonids. Fidelity to relatively small home ranges probably explains why virtually all of the walleye captured and released in the southeastern portion of the lake remained there for the duration of the study.

Temperature influences

During the non-spawning season, implanted walleye moved more when water temperatures were < 10 °C (77 m/d) than when they were higher (22 m/d). However, data was not collected during periods of ice cover when the water temperatures would have been the lowest. The increased activity at temperatures <10 °C may have been caused by pre-spawning behaviors rather than normal activities (e.g. foraging). The reduction in activity at higher temperatures was consistent with walleye activity in Lake Bemidji (Holt *et al.* 1977). High summer water temperatures > 25 °C appear to limit walleye movements to brief periods after sunset. Walleye typically reside in dense macrophyte beds where it is believed that the canopy of the macrophytes provides daytime shade for their sensitive eyes (Einhouse and Winter 1981). Implanted walleye in

Honeoye Lake tended to move from daytime resting spots within macrophyte beds to slightly deeper water at the edge of the beds at night where they were probably feeding.

Assessment of natural walleye reproduction in Honeoye Lake

Apparent spawning runs occurred in the Honeoye Inlet channel during 2002 and 2003 (Figure 3), and three implanted walleye in the lake (140, 341 and 501) appeared to have made spawning movements out of their home ranges (Appendix II. 2, 3, 4). Also, the NYSDEC reported that 5% of the female walleye captured in early spring trap net surveys in Honeoye Lake had already spent their eggs (Hammers *et al.* 2001). These observations imply the possibility of two distinct walleye spawning populations, lentic and lotic, in Honeoye Lake.

The absence of naturally produced walleye fry in potential lotic and lentic spawning habitats in the Honeoye Lake system may be a product of poor egg survival or severe predation on the walleye fry. Honeoye Lake no longer contains an open water planktivore, such as the alewife (*Alosa psuedoharengus*), so predation is probably not a major source of mortality (Forney 1986). Only a few areas in Honeoye Lake, mostly along the southeastern shore, have gravel substrates; they are typically at the mouths of intermittent tributaries and tend to be very steep. Eschmeyer (1950) reported that steep near-shore areas were not utilized as spawning sites by walleye. In Honeoye Lake, it is likely that walleye are forced to deposit their eggs over unsuitable habitat (organic), leading to poor or no hatching success. Johnson (1961) reported the lowest survival rate (0.6-4.6% survival) for walleye eggs spawned over muck-detritus substrates. Therefore, it is unlikely that eggs deposited by walleye at these locations in Honeoye Lake survived to hatch.

Actual spawning of eggs and milt was observed in the Honeoye Inlet channel, and spent females were also captured in the trap net, confirming that a lotic spawning run occurred in Honeoye Lake, especially in 2003. The lower reaches of the Honeoye Inlet channel are not considered to be suitable walleye spawning habitat (Hammers *et al.* 2001); however, once the man-made Honeoye Inlet channel connects with the original Honeoye Inlet stream the substrate changes dramatically. The Honeoye Inlet stream bed contains salmonids and the substrate appears to be excellent walleye spawning habitat based on visual inspection. Walleye have been anecdotally reported in this stream during the spawning season. Fish 651 traveled the farthest up the Honeoye Inlet channel but failed to reach the original Honeoye Inlet stream. The Honeoye Inlet channel diverges from the Honeoye Inlet stream at a culvert that becomes blocked with debris periodically. Walleye have been observed at the culvert with a spotlight during the spawning season. If access to the Honeoye Inlet stream were available during the spawning season it is possible that walleye would spawn on the gravel substrate. However, any walleye fry produced in the Honeoye Inlet stream would have to over-come obstacles to survival, including slow moving water, siltation, beaver dam obstruction and predators during out-migration through the Honeoye Inlet channel to Honeoye Lake.

Walleye exhibit an inherited preference for lotic or lentic spawning habitats (Jennings *et al.* 1996). The walleye population in Honeoye Lake is maintained by stocking fry from broodstock from Oneida Lake that originates from both lotic and lentic spawning populations (Colesante 1996). The gene or combination of genes for lotic and lentic spawning habitat preference are mixed at the hatchery when the gametes from lotic and lentic broodstock are combined, so many of the 8.7 million walleye fry that Honeoye

Lake receives are hybrids of lotic and lentic spawning parents. Therefore, the lack of spawning success of walleye in Honeoye Lake may be due to "genetic confusion," not inadequate spawning habitat. Even so, very little suitable spawning habitat appears to be available in the Honeoye Lake system.

Recommendations

1) The Honeoye Inlet channel and Honeoye Inlet stream should be evaluated for potentially suitable spawning habitat according to the Habitat Suitability Index (HSI) of McMahon *et al.* (1984).
2) The benthic substrate of the near-shore of Honeoye Lake should be mapped to identify potentially suitable habitats, which should also be evaluated according to the Habitat Suitability Index (HSI) of McMahon *et al.* (1984).
3) Determine which spawning habitat type (lotic or lentic) is most suitable or most feasible to manipulate for successful walleye reproduction. Artificial spawning "reefs" have been constructed with some success (Dustin and Jacobsen 2003).
4) Customize fry production and stockings to take advantage of inherited preferences for certain spawning habitats. HSI findings may identify which habitat prefernce, lentic or lotic, should be selected from parent broodstock.
5) Scale samples should be taken in the future from walleye collected in Honeoye Lake to validate an absence of the 2002 year-class (no fry were stocked).

SUMMARY OF FINDINGS

1. Of the 23 tagged walleye, seven transmitters (30%) were harvested by anglers, suggesting that harvest rates of walleye in Honeoye Lake are high or that tagged walleye are more susceptible than untagged to harvest.
2. With the exception of one walleye (061) that entered the Honeoye Inlet channel while the lake was still frozen on 14 March 2002, the spawning season ran from ice-out (28 March; 5.2-8.3°C) until 10 and 17 April (13.7-7.7°C) in 2002 and 2003, respectively.
3. During the spawning season, walleye were often located in the inlet channel or over gravel to boulder substrate along the southeastern shore of Honeoye Lake, but many fish were located over habitats unsuitable for spawning success.
4. During the non-spawning season, all but one walleye's home range was along the southeastern shore of Honeoye Lake, coinciding with their site of capture.
5. Walleye moved more during the spawning than the non-spawning season and when water temperature was <10°C.
6. No naturally reproduced walleye eggs and fry were collected, but stocked walleye fry and naturally reproduced yellow perch fry were, suggesting that there is little or no natural reproduction of walleye in Honeoye Lake. The most likely explanation for this is that walleye do not spawn over suitable substrates for egg survival and hatching.

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Table 1. Biological, tagging and tracking data for implanted walleye from Honeoye Lake, 2001-2003. ND = no data.

Release date	Frequency (53 MHz)	Length (mm)	Weight (g)	Sex	Age	Floy Tag #	Duration of surgery (min)	Release site	Reported harvest date	Last contact date	Tracking duration (d)
11/13/2001	161	490	1022	F	3	26	13	SE shore	1/20/2002	12/31/2001	48
11/13/2001	341	532	1258	F	4	27	8	SE shore	9/2/2002	8/4/2002	232
11/13/2001	140	479	1046	F	4	28	5	SE shore		4/3/2003	492
11/13/2001	100	500	1112	F	5	29	ND	SE shore		7/2/2003	582
11/14/2001	081	493	1046	F	6	30	28	SE shore	5/2002	3/8/2002	114
11/14/2001	980	527	1327	F	5	31	15	SE shore		8/14/2003	685
11/14/2001	061	470	903	M	3	33	14	SE shore		8/14/2003	685
11/14/2001	221	523	1215	M	5	34	15	SE shore		8/14/2003	685
11/14/2001	651	494	1080	M	5	35	13	SE shore		8/14/2003	685
11/14/2001	302	491	946	M	4	36	14	SE shore		8/14/2003	685
11/14/2001	501	505	1345	F	5	37	13	SE shore		7/2/2003	581
11/14/2001	322	466	900	M	5	38	12	SE shore		8/14/2003	685
11/14/2001	702	492	1035	M	5	39	15	SE shore	1/17/2002	11/14/2001	1
4/3/2002	400	530	1223	F	ND	41	12	SE shore		7/2/2003	424
4/3/2002	702*	519	1215	F	ND	42	25	SE shore	ND	6/19/2002	77
4/3/2002	238	525	1123	F	ND	43	10	SE shore		8/14/2003	436
4/3/2002	023	561	1826	F	ND	44	8	SE shore	5/2002	7/2/2003	393
10/7/2002	122	565	1742	F	6	3412	34	SE shore		8/14/2003	281
4/29/2003	023*	472	NA	F	4	ND	ND	NW shore		7/2/2003	64
4/29/2003	702**	482	NA	F	ND	46	ND	NW shore	6/2/2004	4/29/2003	1
6/16/2003	251	495	1257	M	ND	ND	22	SE shore		8/14/2003	59
6/16/2003	081*	529	1487	F	ND	ND	20	SE shore		7/2/2003	16
6/16/2003	181	554	1492	F	ND	ND	18	SE shore		8/14/2003	59

* re-implanted transmitter
** second re-implantation

Table 2. Movements and home ranges of implanted walleye in Honeoye Lake, 2001-2003. ND = no data.

Frequency (53 MHz)	Spawning period Days	km moved	m/d	Home range (ha)	Non-spawning period Days	km moved	m/d	Home range (ha)
161	ND	ND	ND	ND	ND	ND	ND	ND
341	19	2.47	130	40.9	215	3.85	18	55.5
140	33	3.6	109	ND	249	2.8	11	ND
100	22	4.8	218	608.1	465	16.3	35	139.6
081	19	1.4	74	ND	30	1.02	34	ND
980	33	2.01	61	100.6	482	13.62	28	187.8
061	33	4.03	122	ND	396	9.7	25	21.4
221	33	5.2	158	ND	454	9.24	20	ND
651	4	0.083	20	ND	397	6.39	16	ND
302	33	0.38	12	0.93	502	5.13	10	24.2
501	33	6.67	202	118.4	543	13.84	25	31.8
322	33	0.891	27	29.1	504	8.23	16	40.6
702	ND	ND	ND	ND	ND	ND	ND	ND
400	14	0.56	40	ND	428	5.46	13	ND
702*	ND	ND	ND	ND	ND	ND	ND	ND
238	11	0.082	7	ND	375	0.286	0.8	ND
023	ND	ND	ND	ND	ND	ND	ND	ND
122	2	2.3	1150	ND	294	10.9	37	ND
023*	ND	ND	ND	ND	ND	ND	ND	ND
702**	ND	ND	ND	ND	ND	ND	ND	ND
251	ND	ND	ND	ND	ND	ND	ND	ND
081*	ND	ND	ND	ND	ND	ND	ND	ND
181	ND	ND	ND	ND	ND	ND	ND	ND
N 23	**14**	**14**	**14**	**6**	**14**	**14**	**14**	**7**
Avg -	**23**	**2.5**	**0.17**	**149.7**	**381**	**7.6**	**0.02**	**71.6**
SD -	**11.6**	**2.1**	**0.30**	**228.9**	**140.6**	**4.9**	**0.01**	**65.4**
Min -	**2**	**0.08**	**0.01**	**0.09**	**30**	**0.29**	**0.001**	**21.4**
Max -	**33**	**6.7**	**0.22**	**608**	**543**	**16.3**	**0.04**	**187.8**

* = re-implanted transmitter
** = second re-implantation

Table 3. Density of walleye and yellow perch pelagic fry from catches in 0.5 m plankton net tows in Honeoye Lake, 2002 and 2003. *Post-stock sampling date.

Date	**# of sites**	**Avg. distance of tow (m)**	**Avg. depth of tow (m)**	**Total volume strained (m^3)**	**# walleye**	**Catch/m^3**	**# yellow perch**	**Catch/m^3**	**Lake volume (m^3x10^6)**	**Estimated walleye population (10^6)**	**Estimated y. perch population (10^6)**
4/29/2002	6	388.3	3.5	457.2	0	0	494	1.1	34.8	0	38.2
5/3/2002	6	380.2	3.5	373.1	0	0	560	1.5	34.8	0	52.2
5/7/2002	11	337.7	3.9	662.8	0	0	1901	2.9	34.8	0	100.9
5/8/2002	4	339.8	3.1	266.8	0	0	850	3.2	34.8	0	111.4
4/28/2003	6	253.9	3.3	299.0	0	0	0	0	34.8	0	0
4/29/2003	11	330.0	2.9	712.3	0	0	0	0	34.8	0	0
5/4/2003	4	327.5	2.9	257.1	0	0	22	.086	34.8	0	2.99
5/8/2003*	17	306.8	3.2	1023.4	5	.005	3678	3.6	34.8	.174	125.3
Total or Average	65	381.2	3.3	4051.7	5	.0006	7505	1.54			

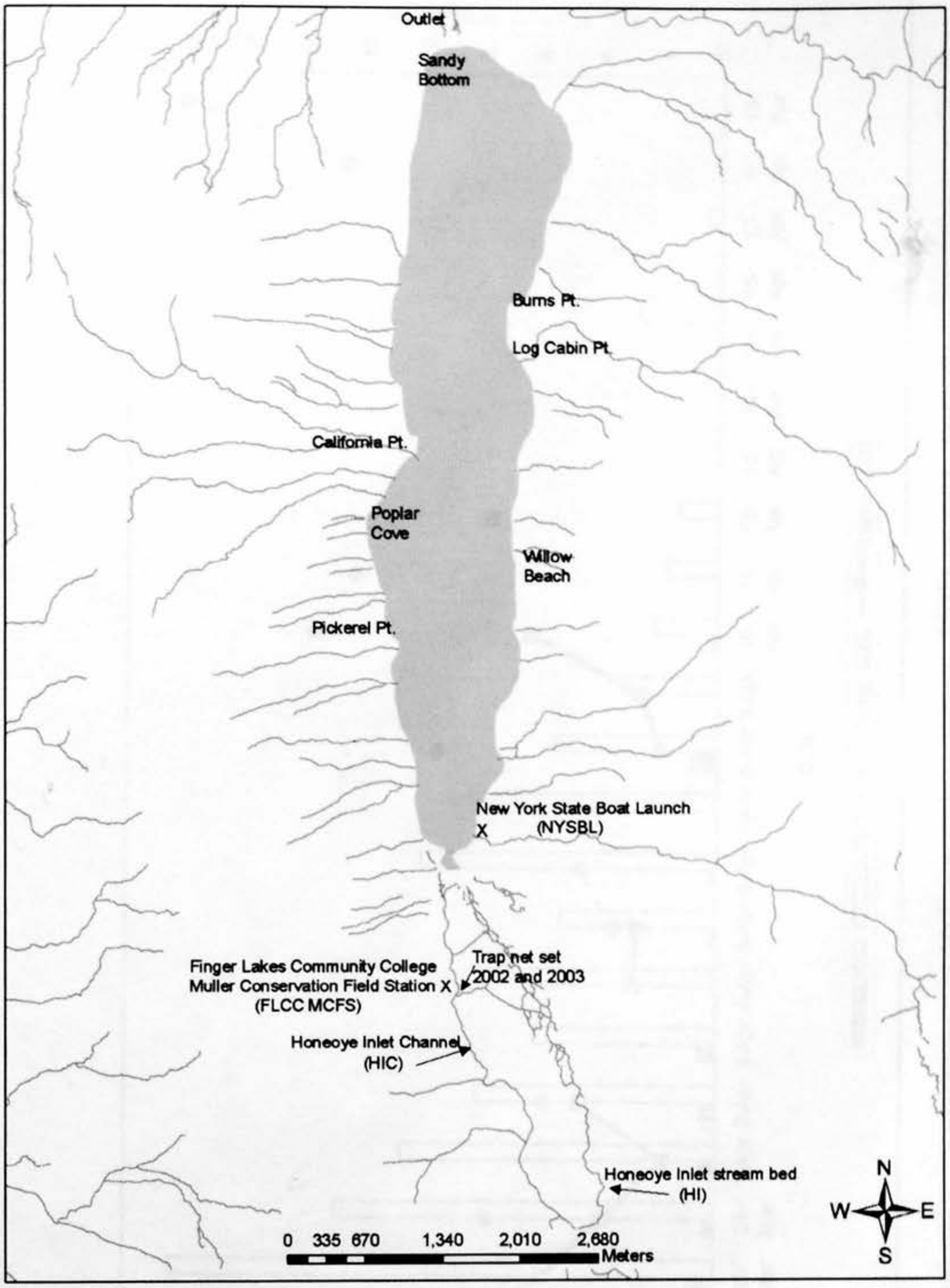


Figure 1. Honeoye Lake study area, 2001-2003. The Honeoye Inlet channel (HIC) and Honeoye Inlet stream (HI) are expanded in Figure 3.

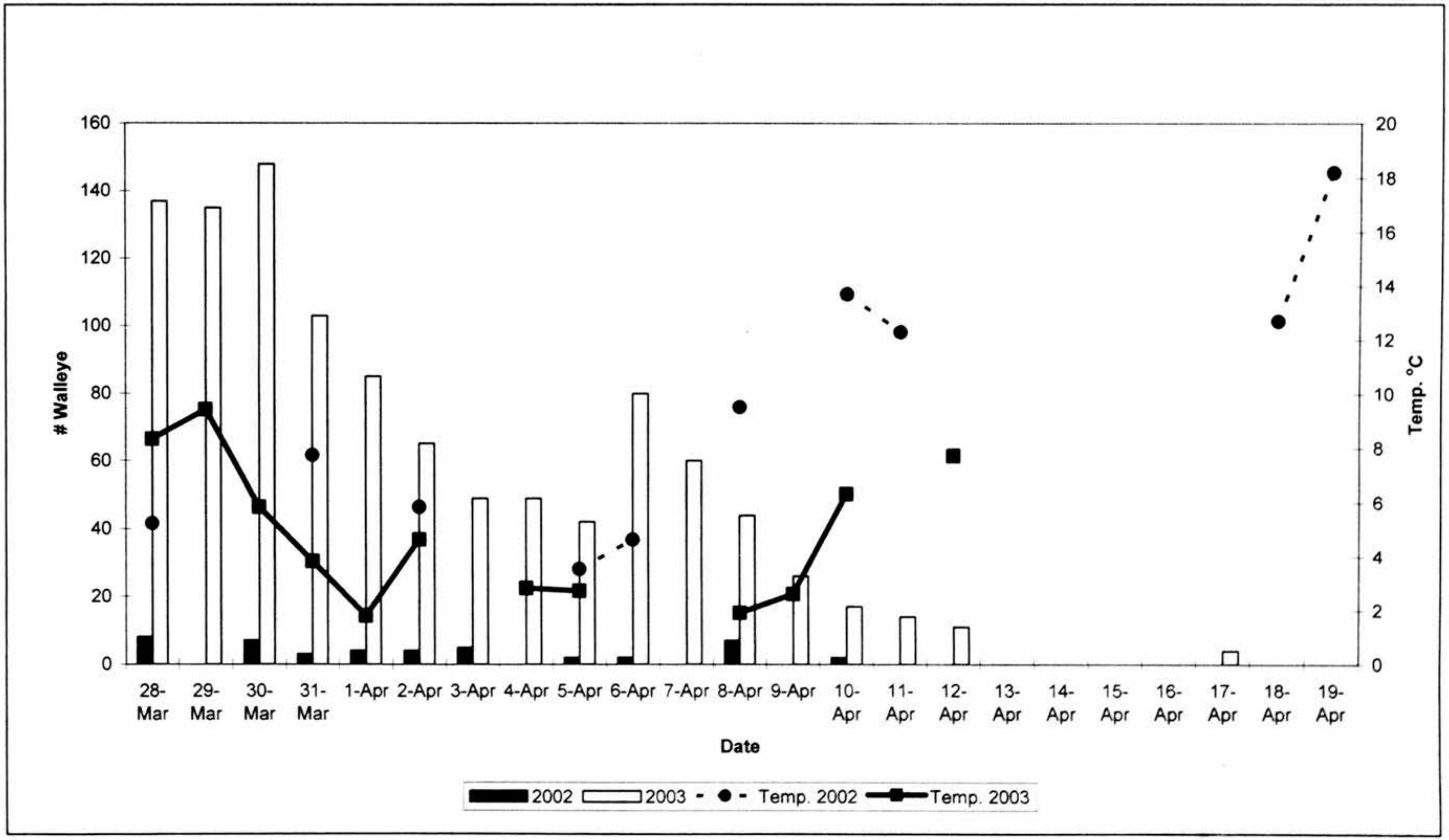


Figure 2. Walleye trappd and water temperature in the Honeoye Inlet channel, 2002 and 2003. Intermittent temperature data was due to the lack of an automatic temperature data logger.

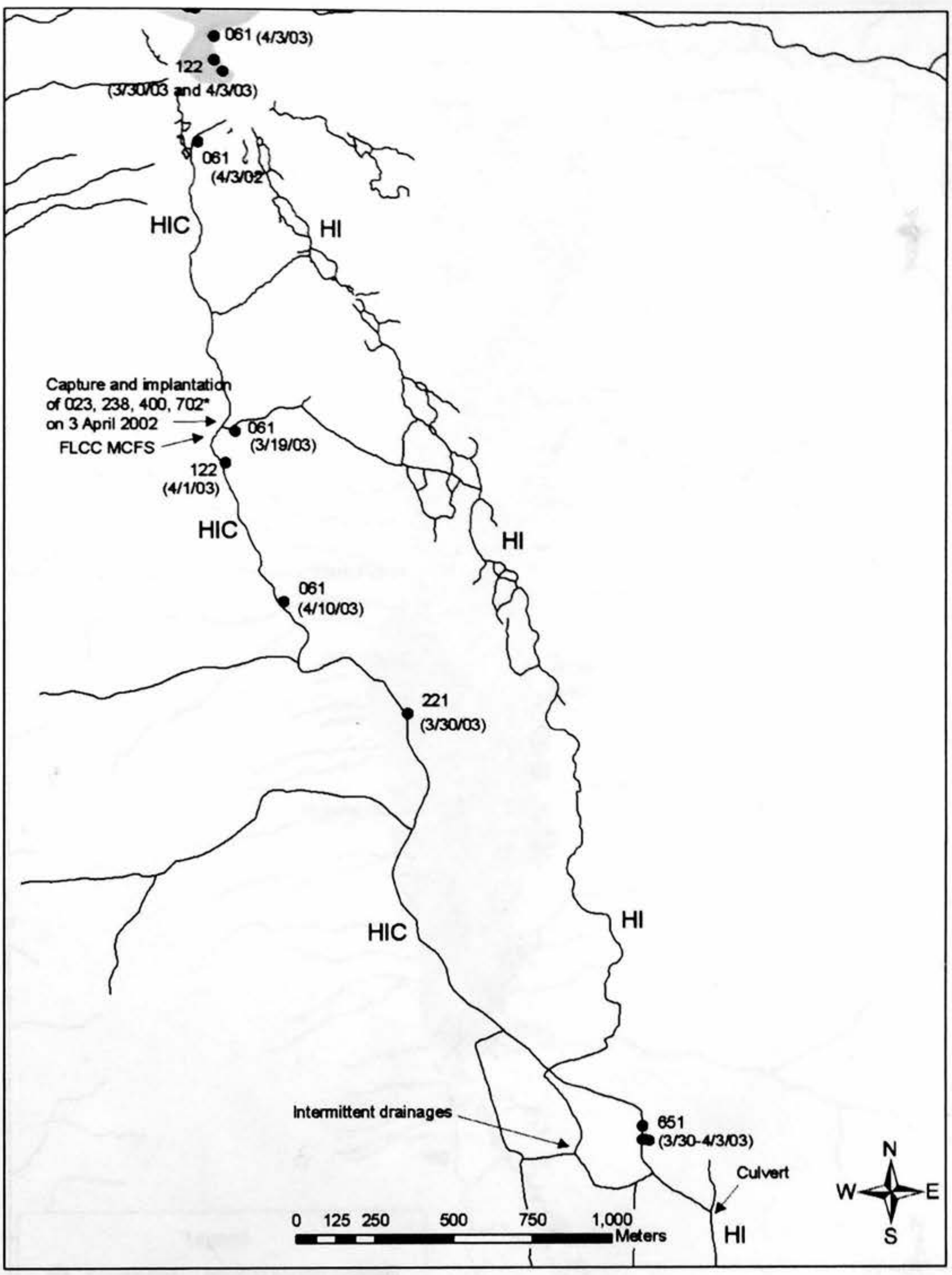


Figure 3. Honeoye Inlet channel (HIC) and Honeoye Inlet stream (HI) containing potential spawning locations for walleye, 2002-2003.

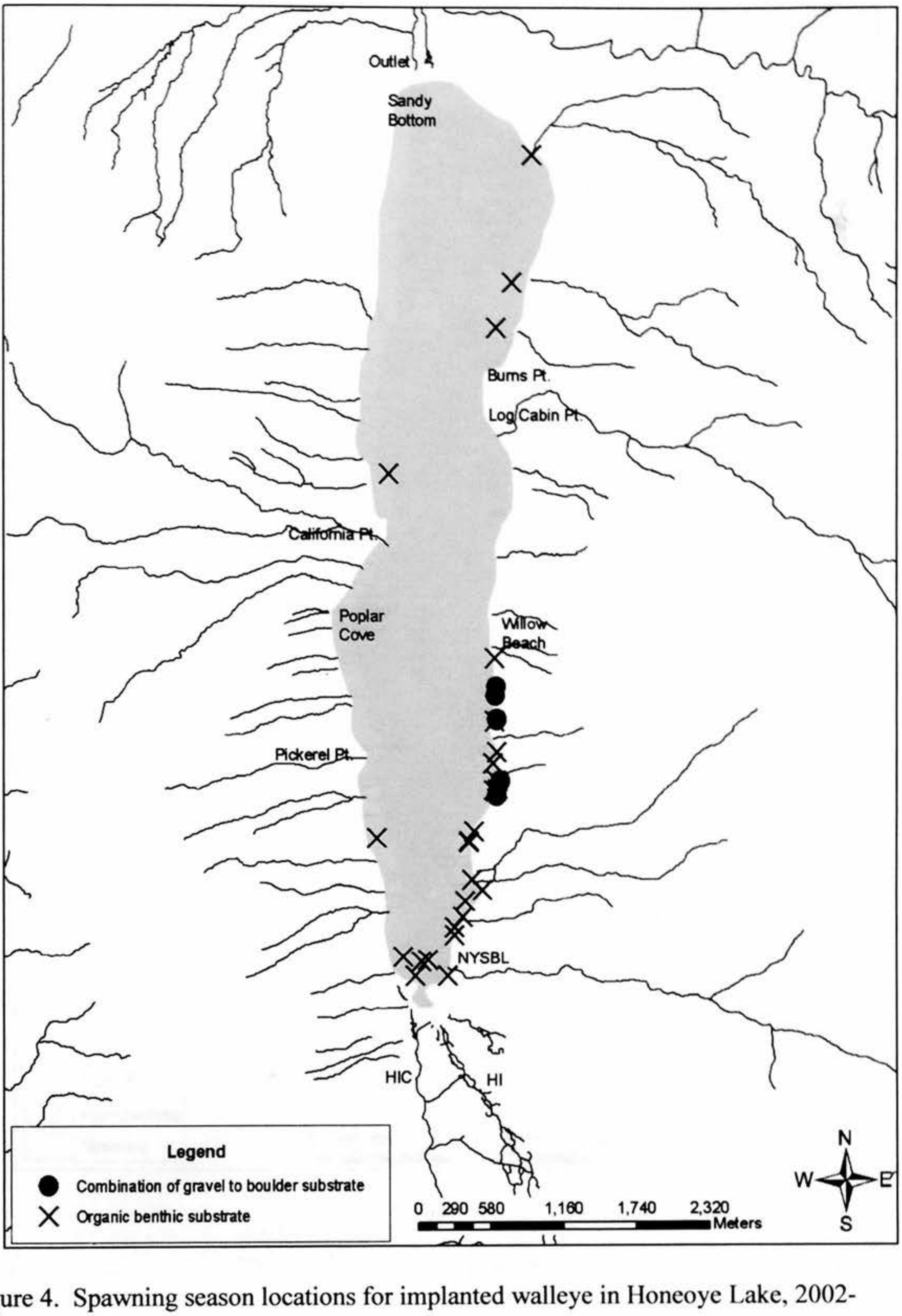


Figure 4. Spawning season locations for implanted walleye in Honeoye Lake, 2002-2003.

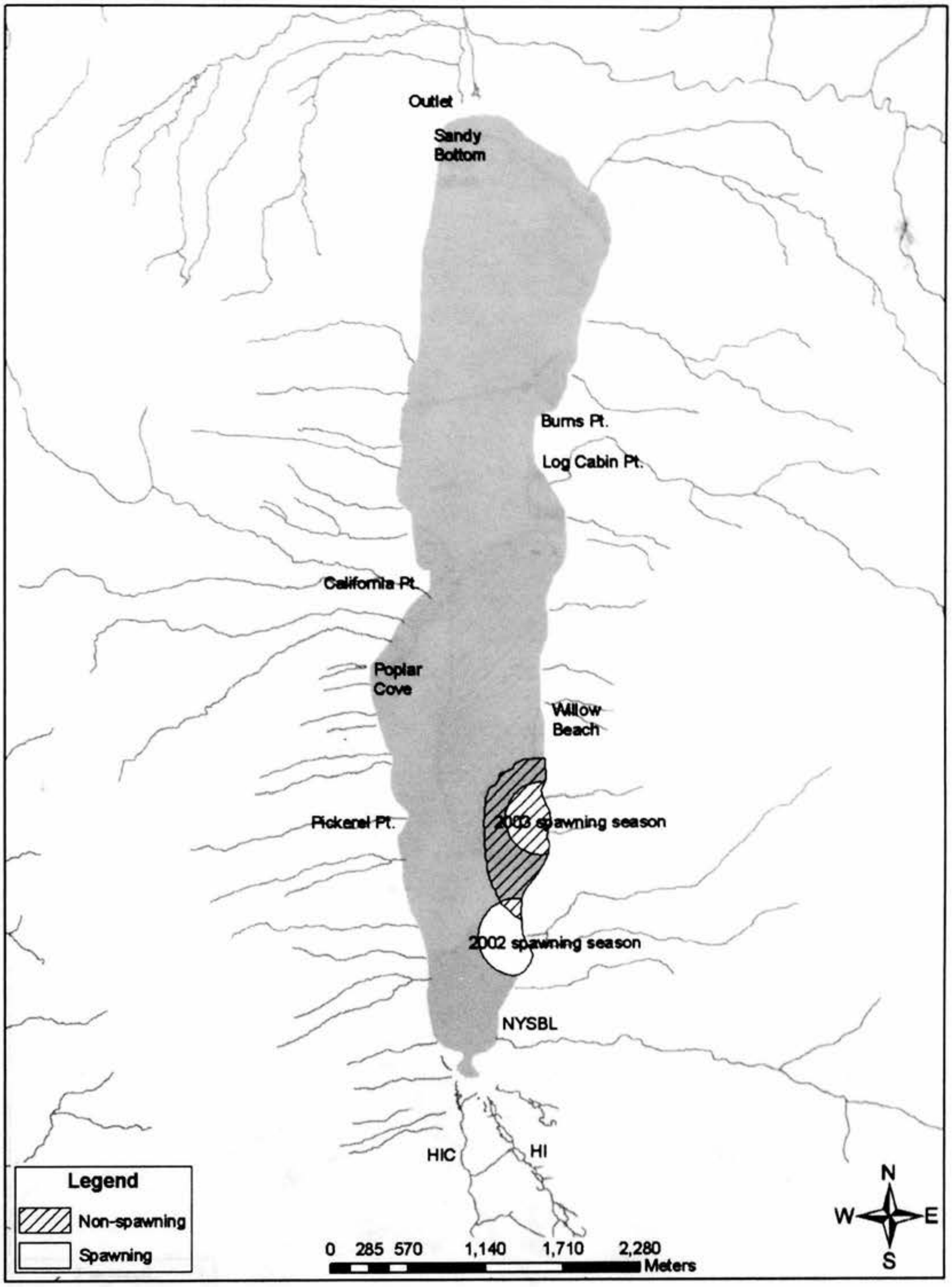


Figure 5. Spawning season home range polygons for fish 322 in Honeoye Lake, 2002-2003.

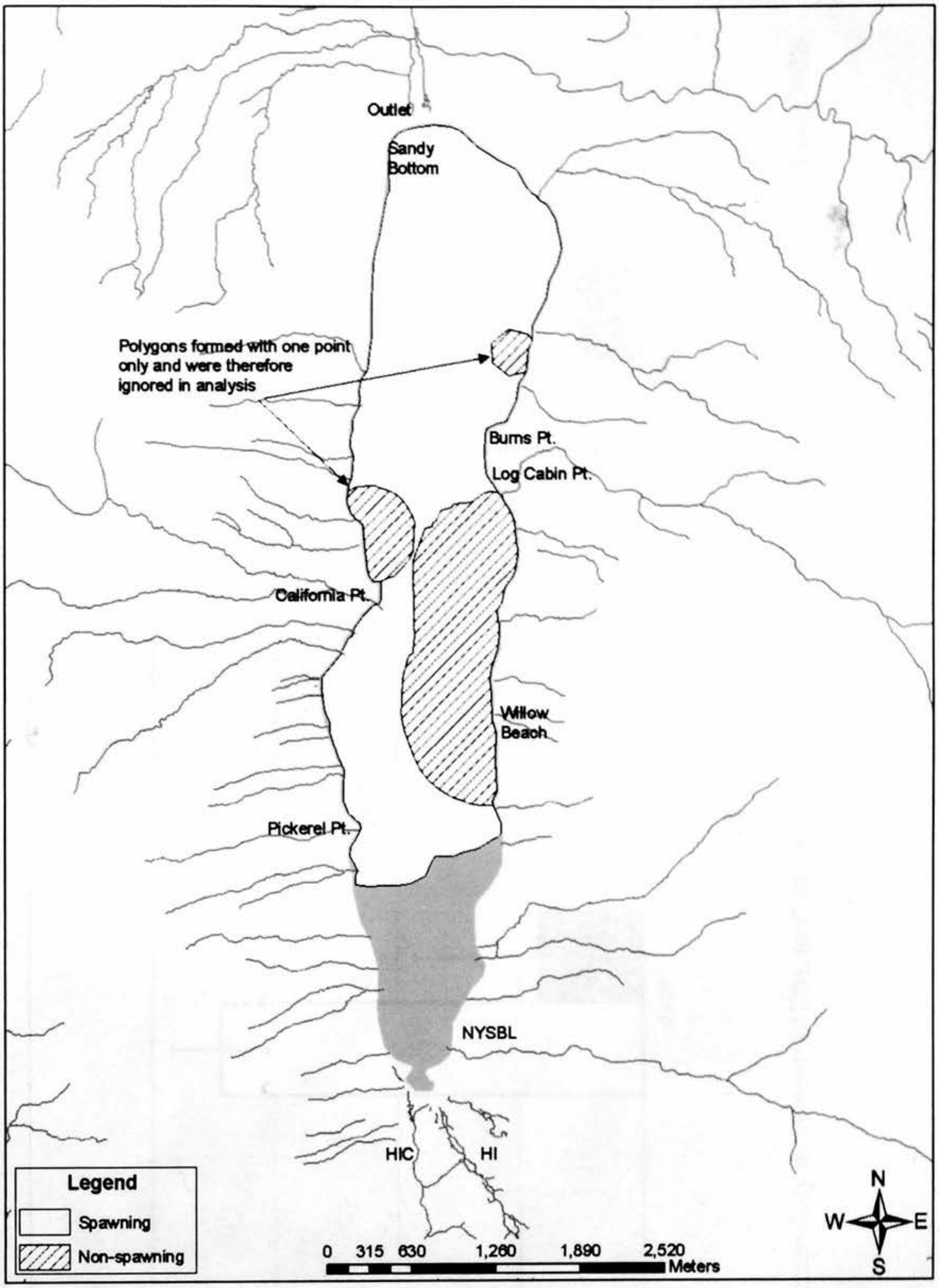


Figure 6. Home range polygons for fish 100 in Honeoye Lake, 2002-2003.

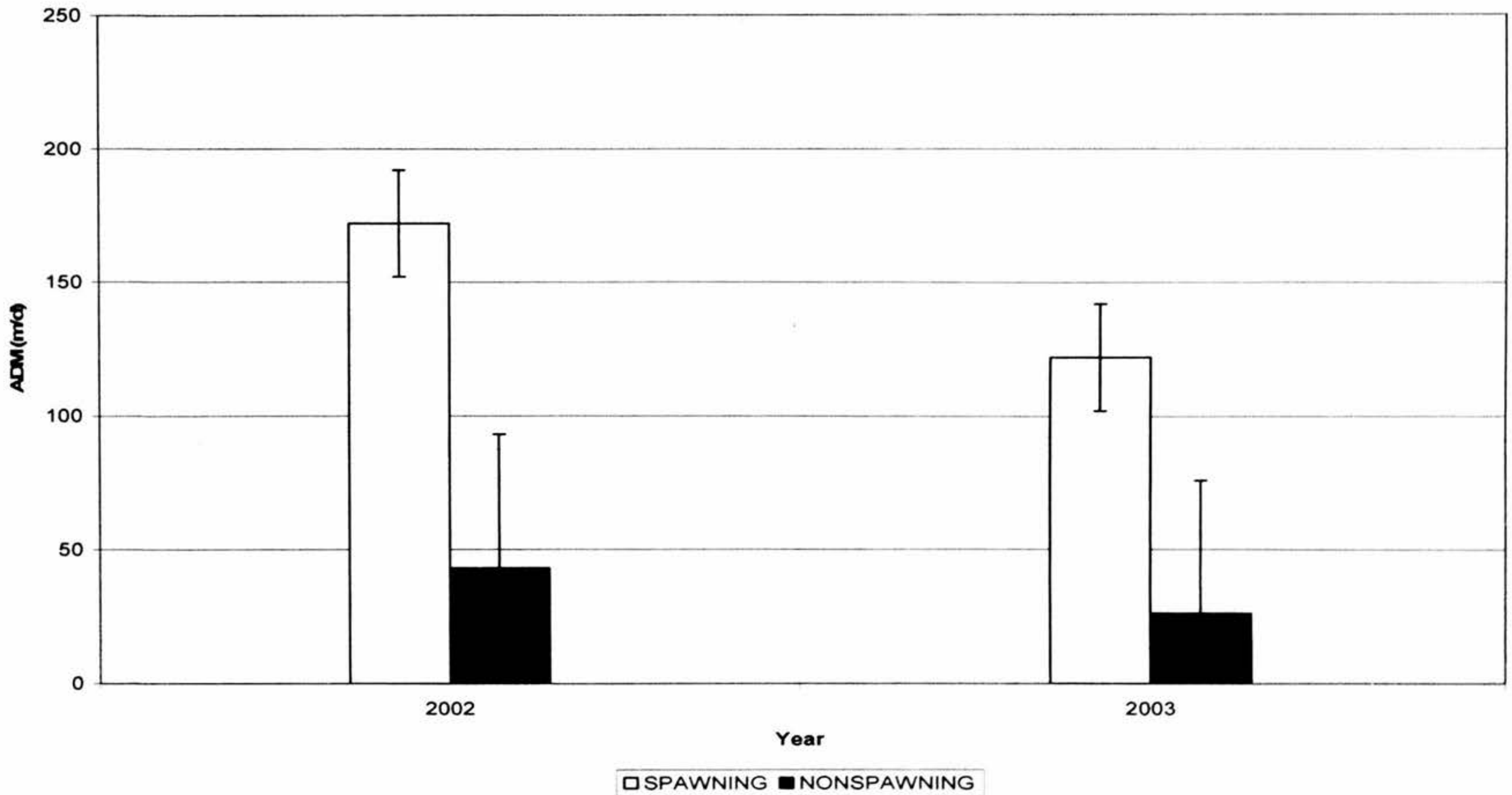


Figure 7. Average daily movements (ADM, m/d) of walleye during spawning and non-spawning seasons in Honeoye Lake, 2002-2003.

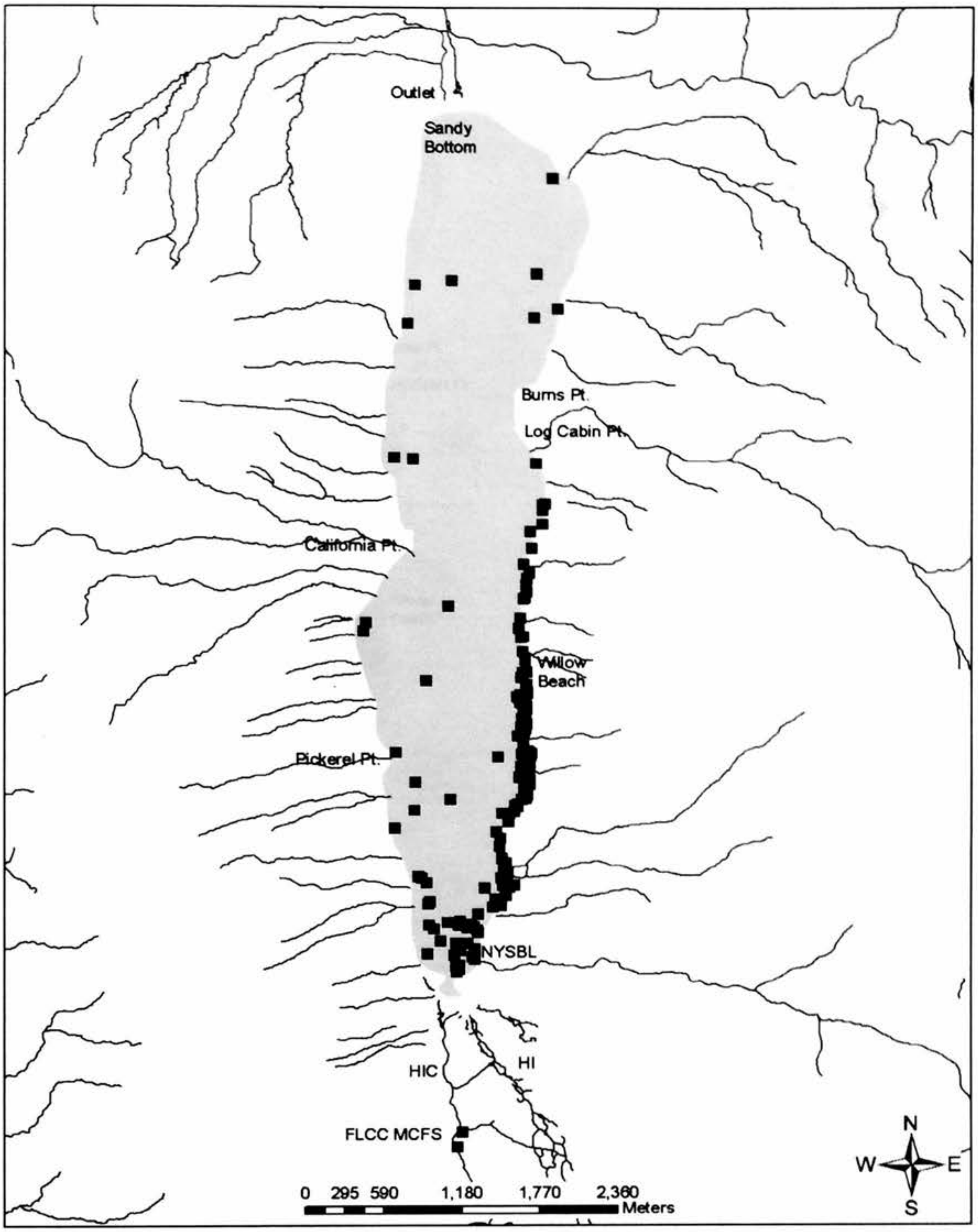


Figure 8. Non-spawning season locations for 23 implanted walleye in Honeoye Lake, 2001-2003.

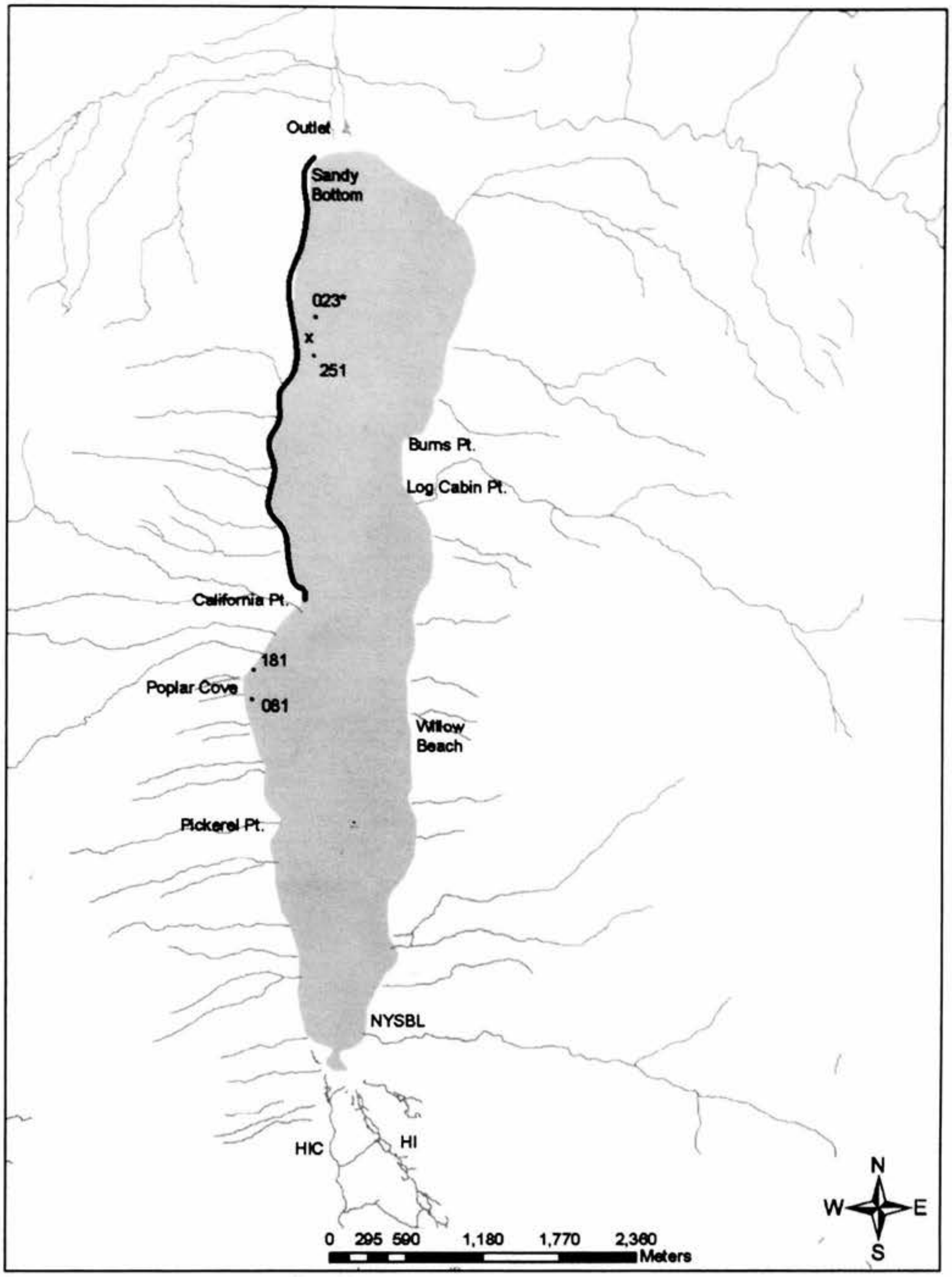


Figure 9. Walleye locations after displacement or no displacement from an area of capture in Honeoye Lake, 2003. The capture area for fish 023*, 702**, 251, 081*, and 181 is outlined in black. Fish 023* and 702** were released at location X on the northwest shore on 29 April 2003. The other fish were released at the NYSBL on the southeast shore on 16 June 2003. Sites of relocation on 2 July 2003 are shown on the map. Fish 702** was not relocated.

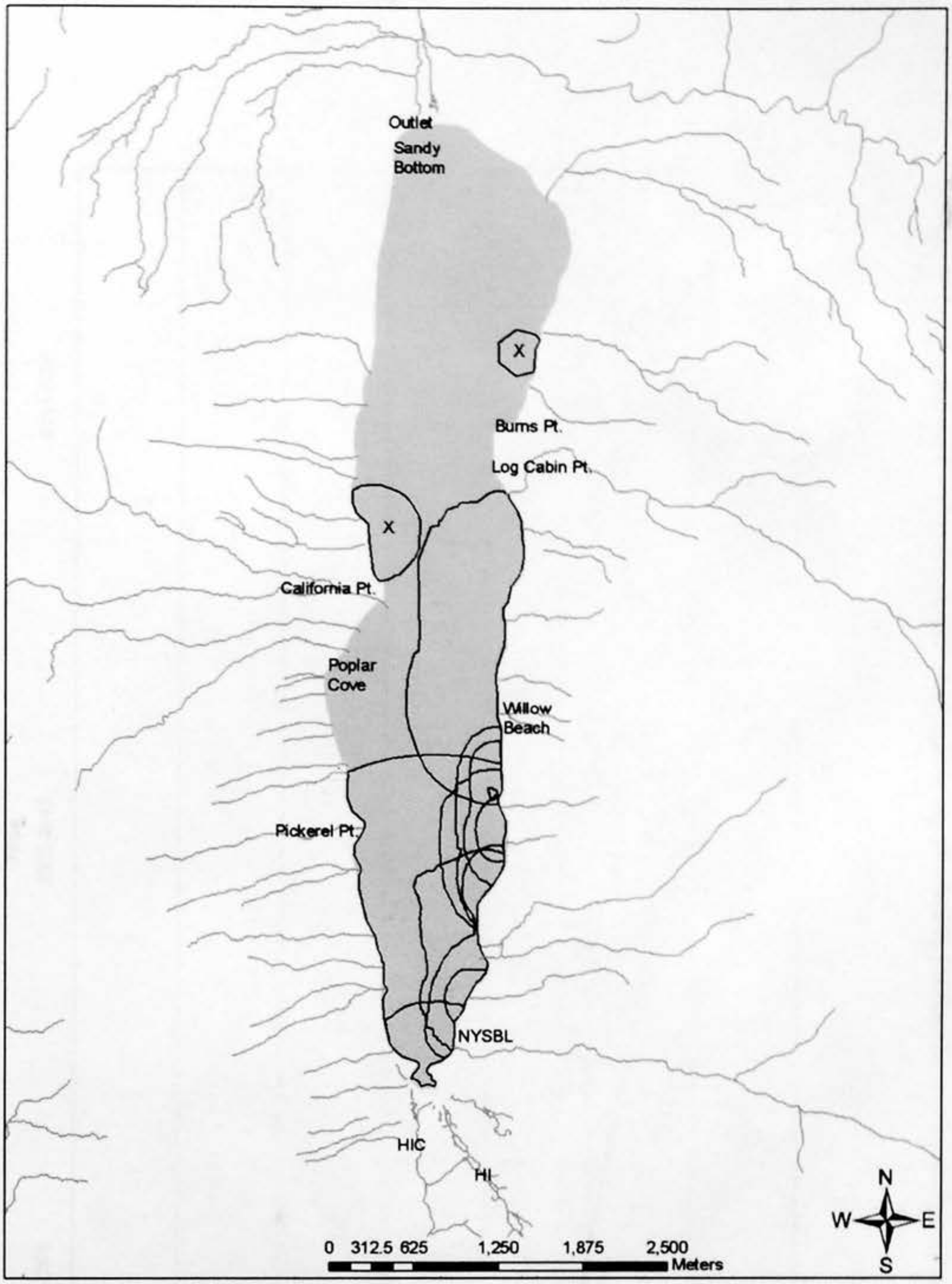


Figure 10. Non-spawning season home range polygons for implanted walleye in Honeoye Lake, 2002-2003. Polygons identified with X are from fish 100 (Figure 6) and were treated as outliers in the analysis.

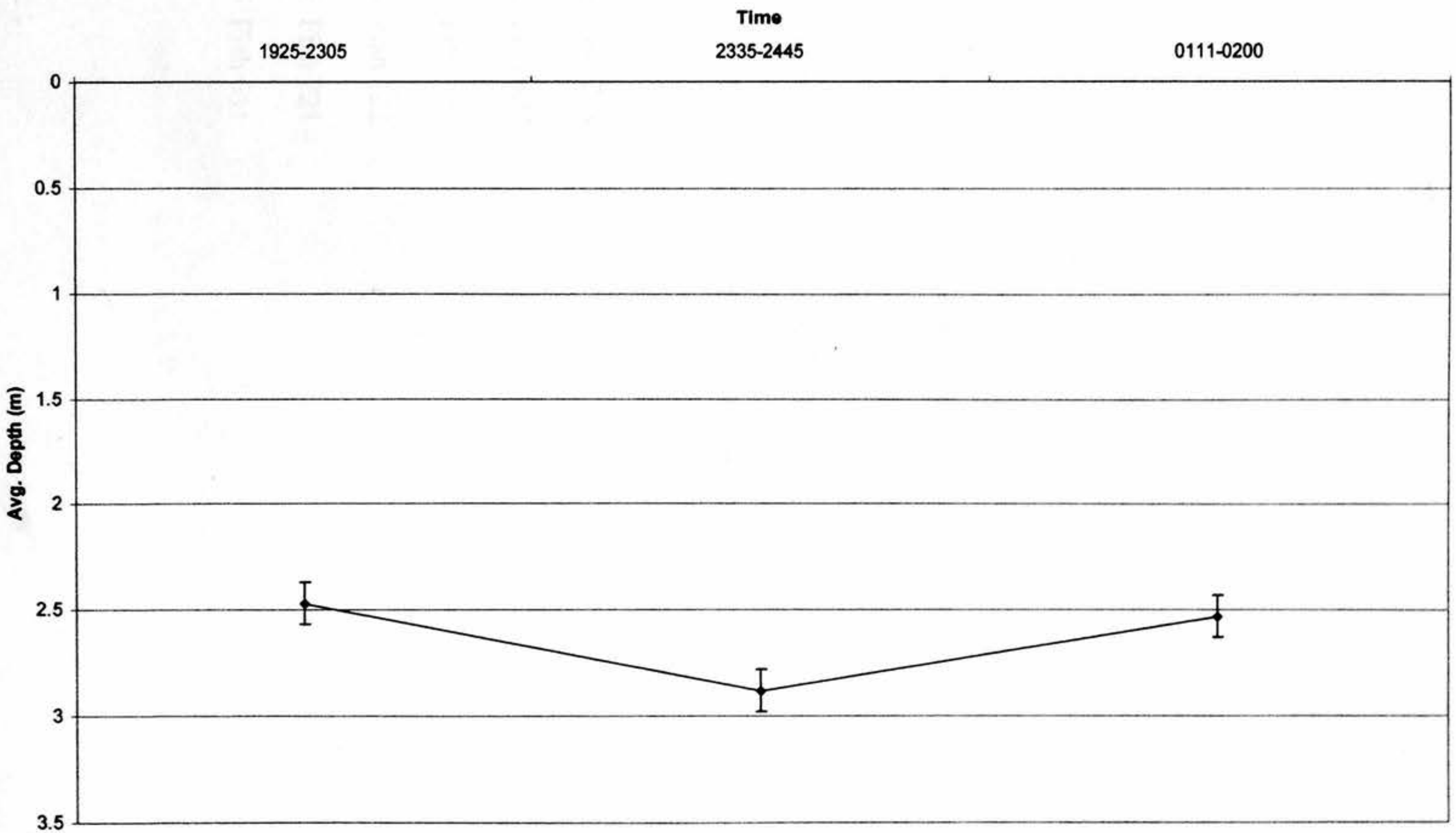


Figure 11. Depth comparisons of successive nocturnal locations for implanted walleye in Honeoye Lake, 23 July 2002.

Appendix I

Locations of walleye in the Honeoye Lake system, 2001-2003. TD = total straight-line distance (km) between locations. DE = days elapsed between locations. m/d = TD/DE multiplied by 1000 for conversion to meters. ■ = locations during the non-spawning season. ● = locations during the spawning season.

I.1 Fish 238

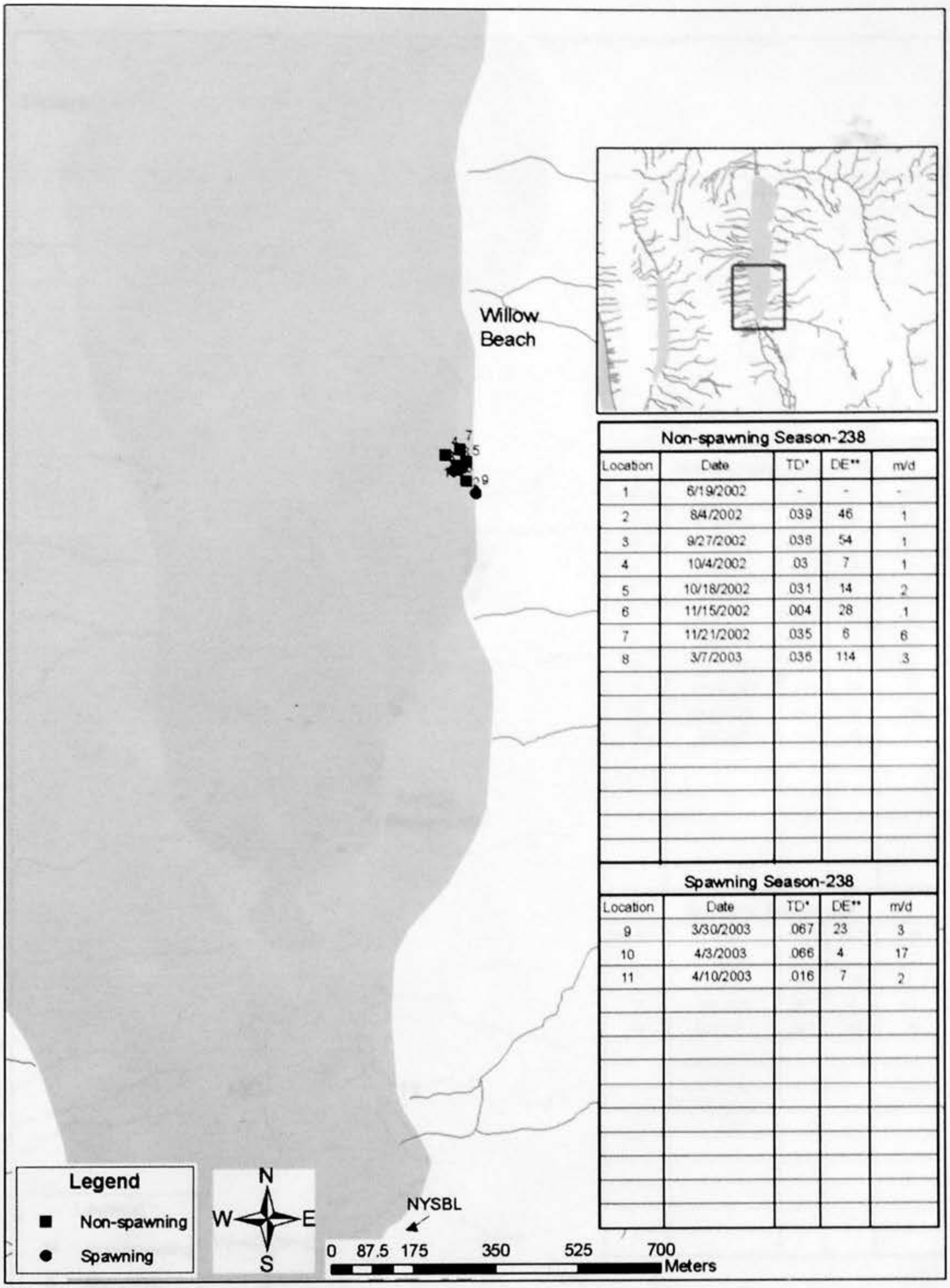
I.2 Fish 400

I.3 Fish 061

I.4 Fish 122

I.5 Fish 221

I.6 Fish 651



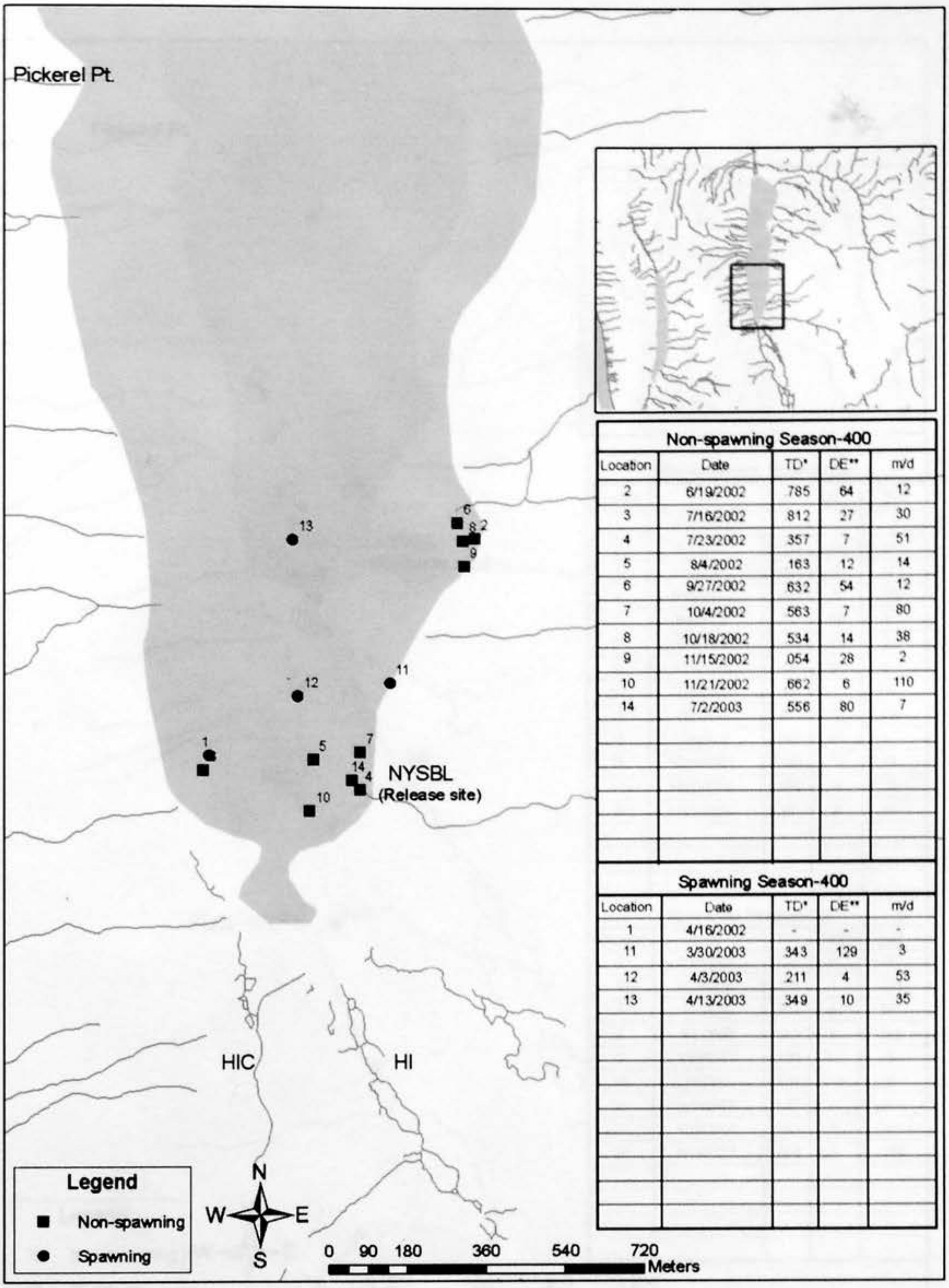
Non-spawning Season-238

Location	Date	TD*	DE**	m/d
1	6/19/2002	-	-	-
2	8/4/2002	039	46	1
3	9/27/2002	036	54	1
4	10/4/2002	03	7	1
5	10/18/2002	031	14	2
6	11/15/2002	004	28	1
7	11/21/2002	035	6	6
8	3/7/2003	036	114	3

Spawning Season-238

Location	Date	TD*	DE**	m/d
9	3/30/2003	.067	23	3
10	4/3/2003	.066	4	17
11	4/10/2003	.016	7	2

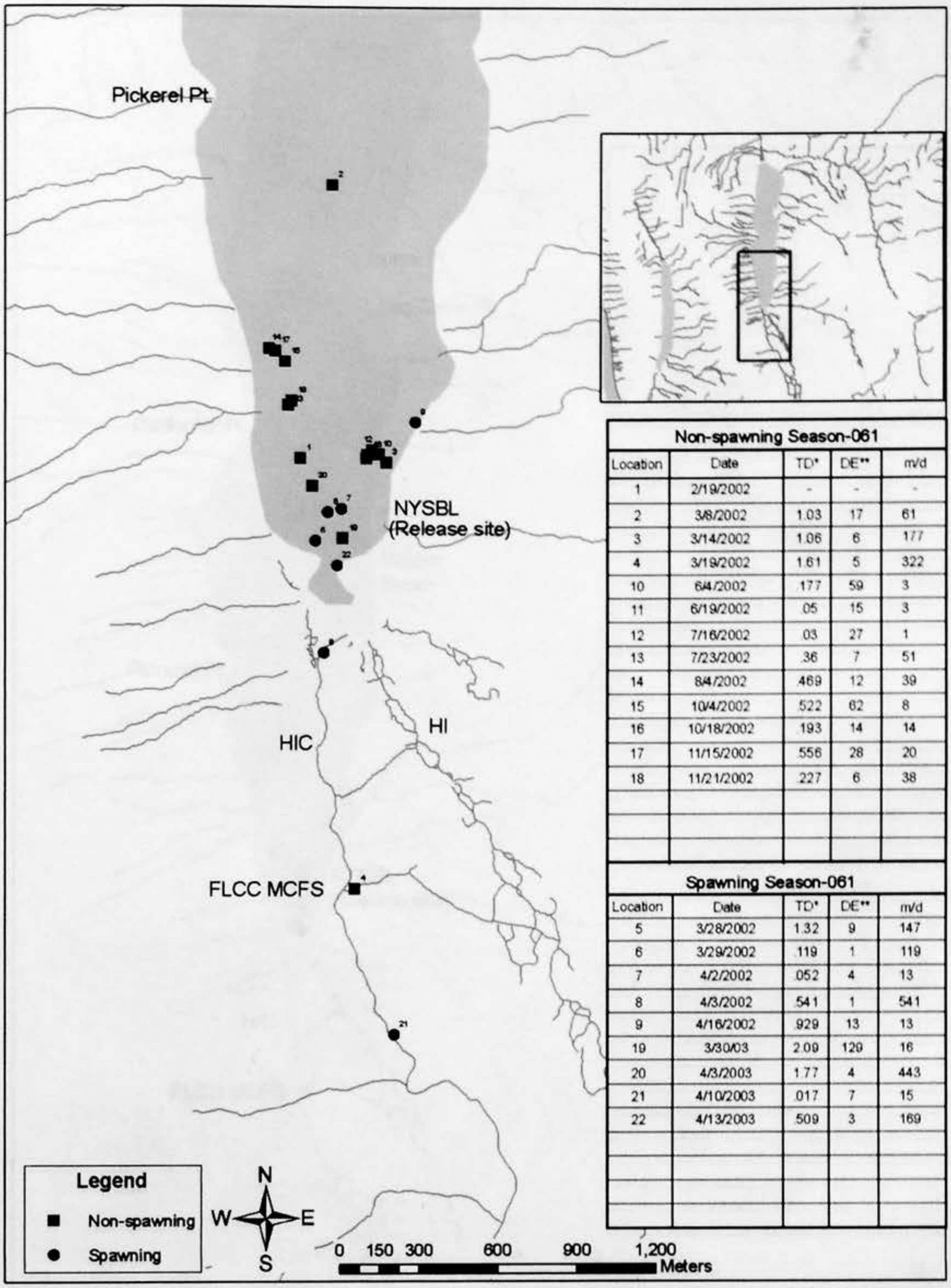
Appendix I.1 Fish 238



Non-spawning Season-400				
Location	Date	TD*	DE**	m/d
2	6/19/2002	785	64	12
3	7/16/2002	812	27	30
4	7/23/2002	357	7	51
5	8/4/2002	163	12	14
6	9/27/2002	632	54	12
7	10/4/2002	563	7	80
8	10/18/2002	534	14	38
9	11/15/2002	054	28	2
10	11/21/2002	662	6	110
14	7/2/2003	556	80	7

Spawning Season-400				
Location	Date	TD*	DE**	m/d
1	4/16/2002	-	-	-
11	3/30/2003	343	129	3
12	4/3/2003	211	4	53
13	4/13/2003	349	10	35

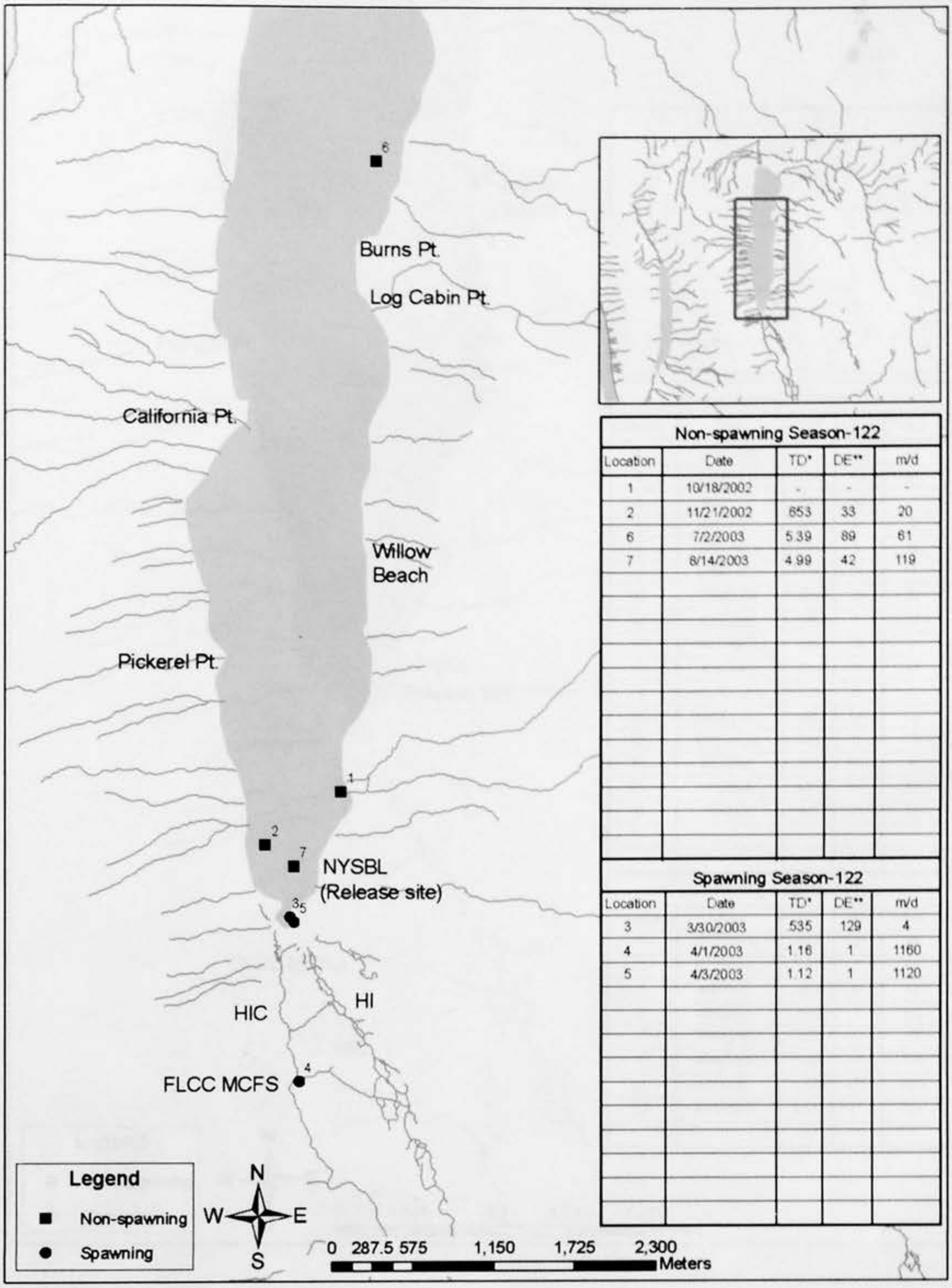
Appendix I.2 Fish 400



Non-spawning Season-061				
Location	Date	TD*	DE**	m/d
1	2/19/2002	-	-	-
2	3/8/2002	1.03	17	61
3	3/14/2002	1.06	6	177
4	3/19/2002	1.61	5	322
10	6/4/2002	.177	59	3
11	6/19/2002	.05	15	3
12	7/16/2002	.03	27	1
13	7/23/2002	.36	7	51
14	8/4/2002	.469	12	39
15	10/4/2002	.522	62	8
16	10/18/2002	.193	14	14
17	11/15/2002	.556	28	20
18	11/21/2002	.227	6	38

Spawning Season-061				
Location	Date	TD*	DE**	m/d
5	3/28/2002	1.32	9	147
6	3/29/2002	.119	1	119
7	4/2/2002	.052	4	13
8	4/3/2002	.541	1	541
9	4/16/2002	.929	13	13
19	3/30/03	2.09	129	16
20	4/3/2003	1.77	4	443
21	4/10/2003	.017	7	15
22	4/13/2003	.509	3	169

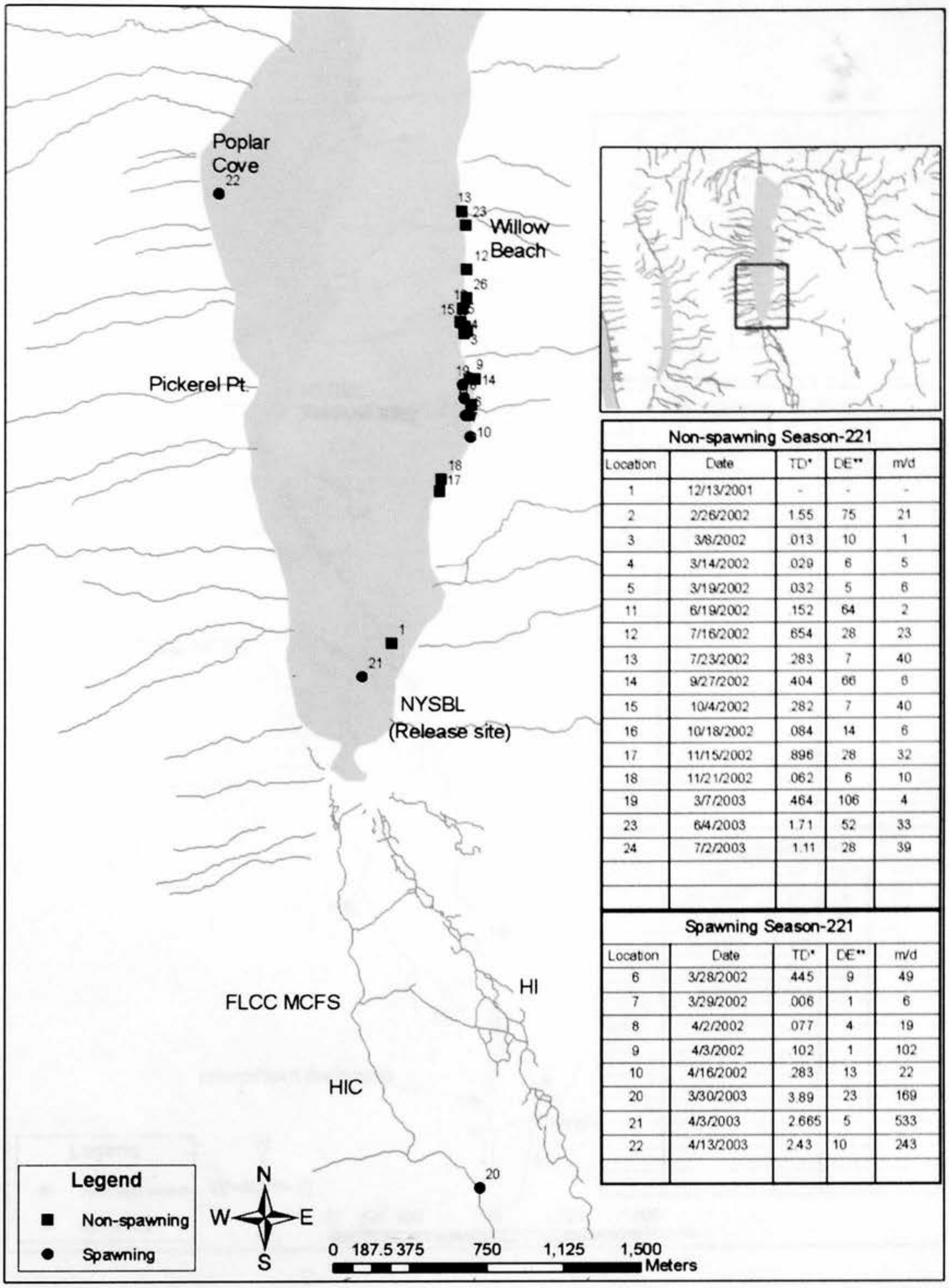
Appendix I.3 Fish 061



Non-spawning Season-122				
Location	Date	TD*	DE**	m/d
1	10/18/2002	-	-	-
2	11/21/2002	653	33	20
6	7/2/2003	5.39	89	61
7	8/14/2003	4.99	42	119

Spawning Season-122				
Location	Date	TD*	DE**	m/d
3	3/30/2003	535	129	4
4	4/1/2003	1.16	1	1160
5	4/3/2003	1.12	1	1120

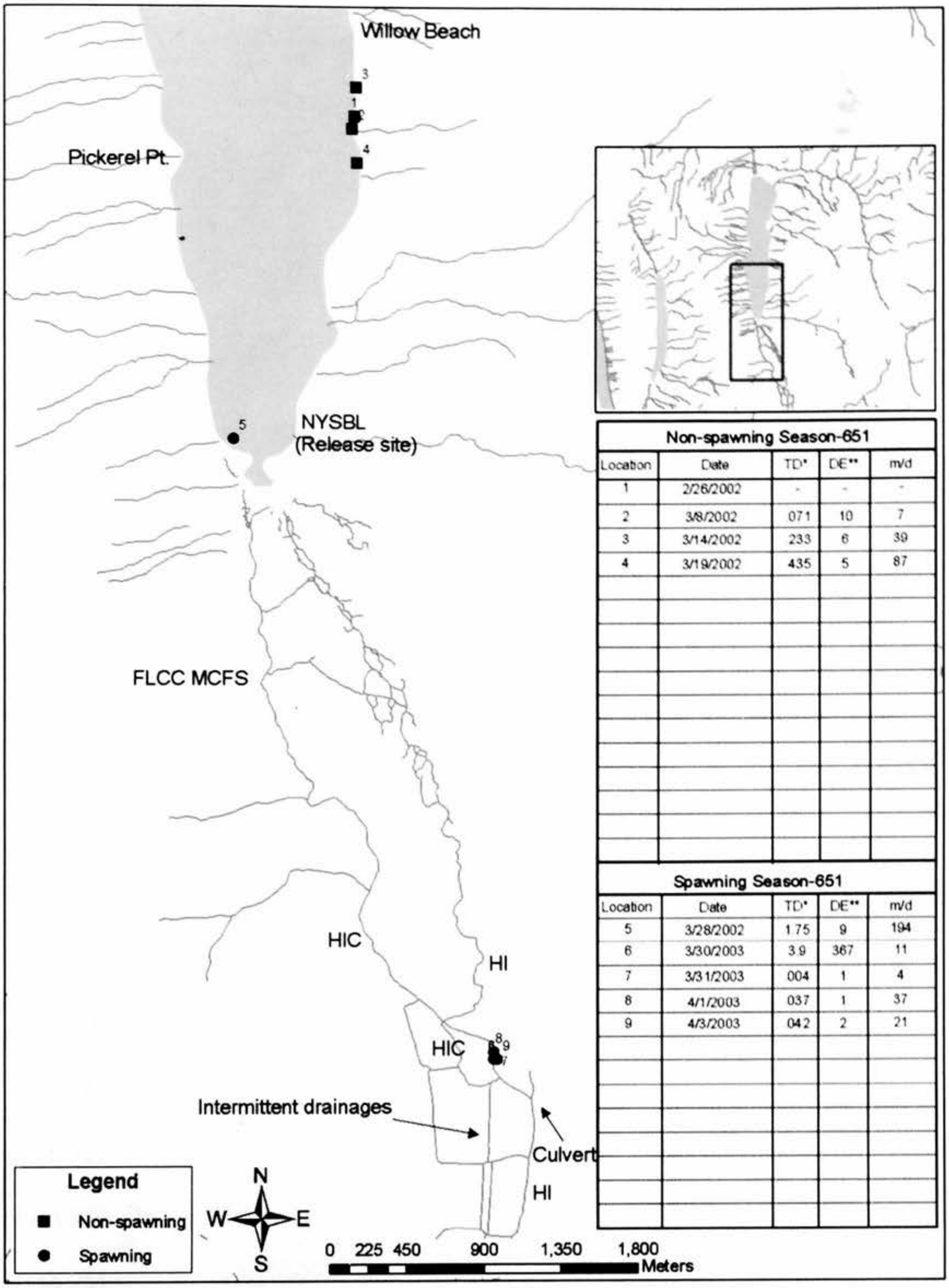
Appendix I.4 Fish 122



Non-spawning Season-221				
Location	Date	TD*	DE**	m/d
1	12/13/2001	-	-	-
2	2/26/2002	1.55	75	21
3	3/8/2002	013	10	1
4	3/14/2002	029	6	5
5	3/19/2002	032	5	6
11	6/19/2002	.152	64	2
12	7/16/2002	654	28	23
13	7/23/2002	.283	7	40
14	9/27/2002	404	66	6
15	10/4/2002	.282	7	40
16	10/18/2002	084	14	6
17	11/15/2002	896	28	32
18	11/21/2002	.062	6	10
19	3/7/2003	464	106	4
23	6/4/2003	1.71	52	33
24	7/2/2003	1.11	28	39

Spawning Season-221				
Location	Date	TD*	DE**	m/d
6	3/28/2002	445	9	49
7	3/29/2002	006	1	6
8	4/2/2002	077	4	19
9	4/3/2002	.102	1	102
10	4/16/2002	.283	13	22
20	3/30/2003	3.89	23	169
21	4/3/2003	2.665	5	533
22	4/13/2003	2.43	10	243

Appendix I.5 Fish 221



Non-spawning Season-651				
Location	Date	TD*	DE**	m/d
1	2/26/2002	-	-	-
2	3/8/2002	071	10	7
3	3/14/2002	233	6	39
4	3/19/2002	435	5	87

Spawning Season-651				
Location	Date	TD*	DE**	m/d
5	3/28/2002	1 75	9	194
6	3/30/2003	3 9	367	11
7	3/31/2003	004	1	4
8	4/1/2003	037	1	37
9	4/3/2003	04 2	2	21

Appendix I.6 Fish 651

Appendix II

Locations of walleye in the Honeoye Lake system, 2001-2003. TD = total straight-line distance (km) between locations. DE = days elapsed between locations. m/d = TD/DE multiplied by 1000 for conversion to meters. ■ = locations during the non-spawning season. ● = locations during the spawning season.

II.1 Fish 100

II.2 Fish 341

II.3 Fish 501

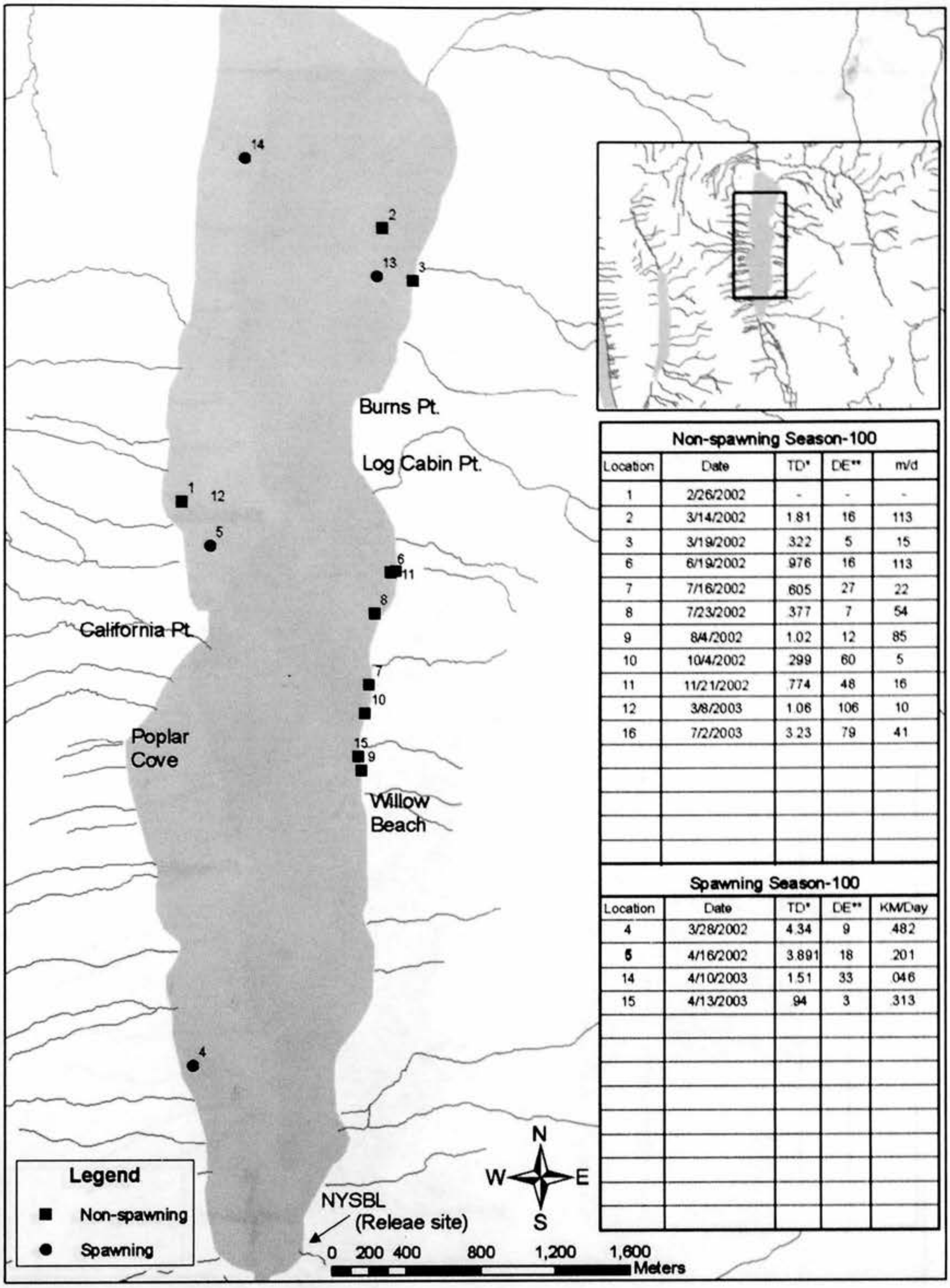
II.4 Fish 140

II.5 Fish 322

II.6 Fish 980

II.7 Fish 081

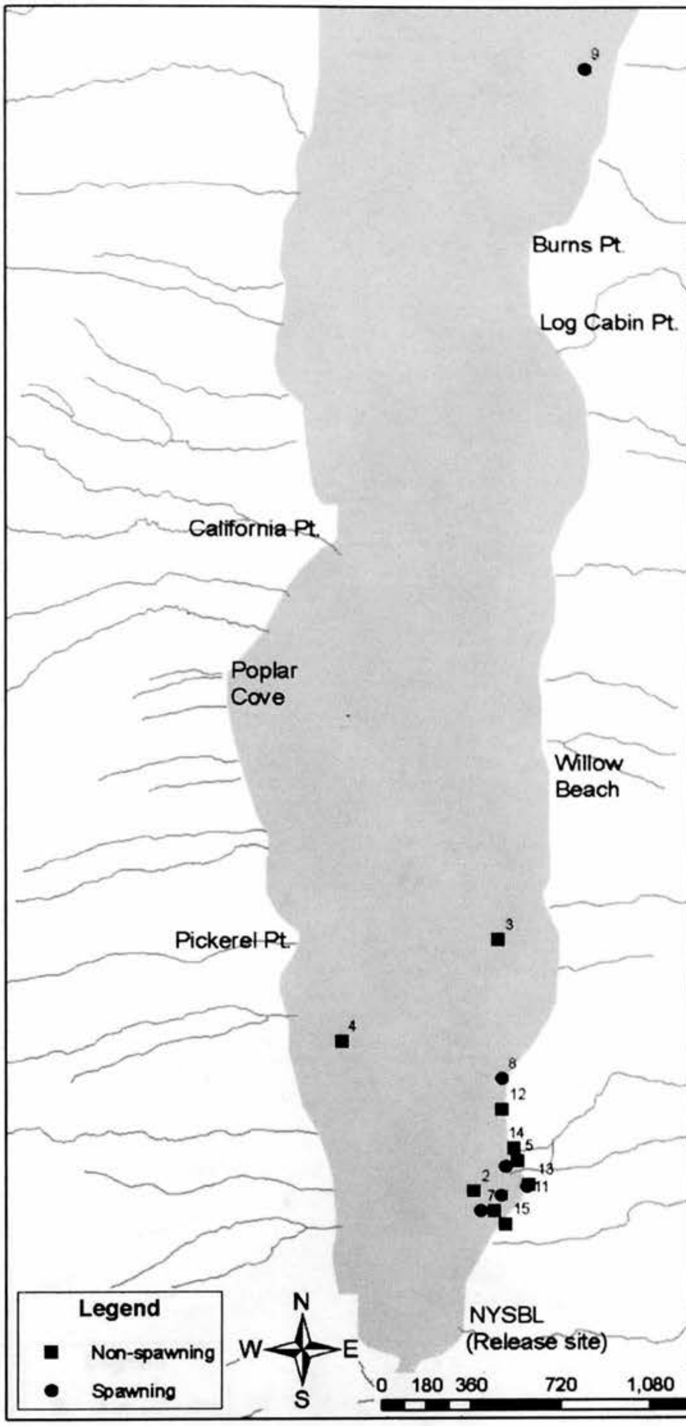
II.8 Fish 302



Non-spawning Season-100				
Location	Date	TD*	DE**	m/d
1	2/26/2002	-	-	-
2	3/14/2002	1.81	16	113
3	3/19/2002	.322	5	15
6	6/19/2002	.976	16	113
7	7/16/2002	.605	27	22
8	7/23/2002	.377	7	54
9	8/4/2002	1.02	12	85
10	10/4/2002	.299	60	5
11	11/21/2002	.774	48	16
12	3/8/2003	1.06	106	10
16	7/2/2003	3.23	79	41

Spawning Season-100				
Location	Date	TD*	DE**	KM/Day
4	3/28/2002	4.34	9	.482
5	4/16/2002	3.891	18	.201
14	4/10/2003	1.51	33	.046
15	4/13/2003	.94	3	.313

Appendix II.1 Fish 100



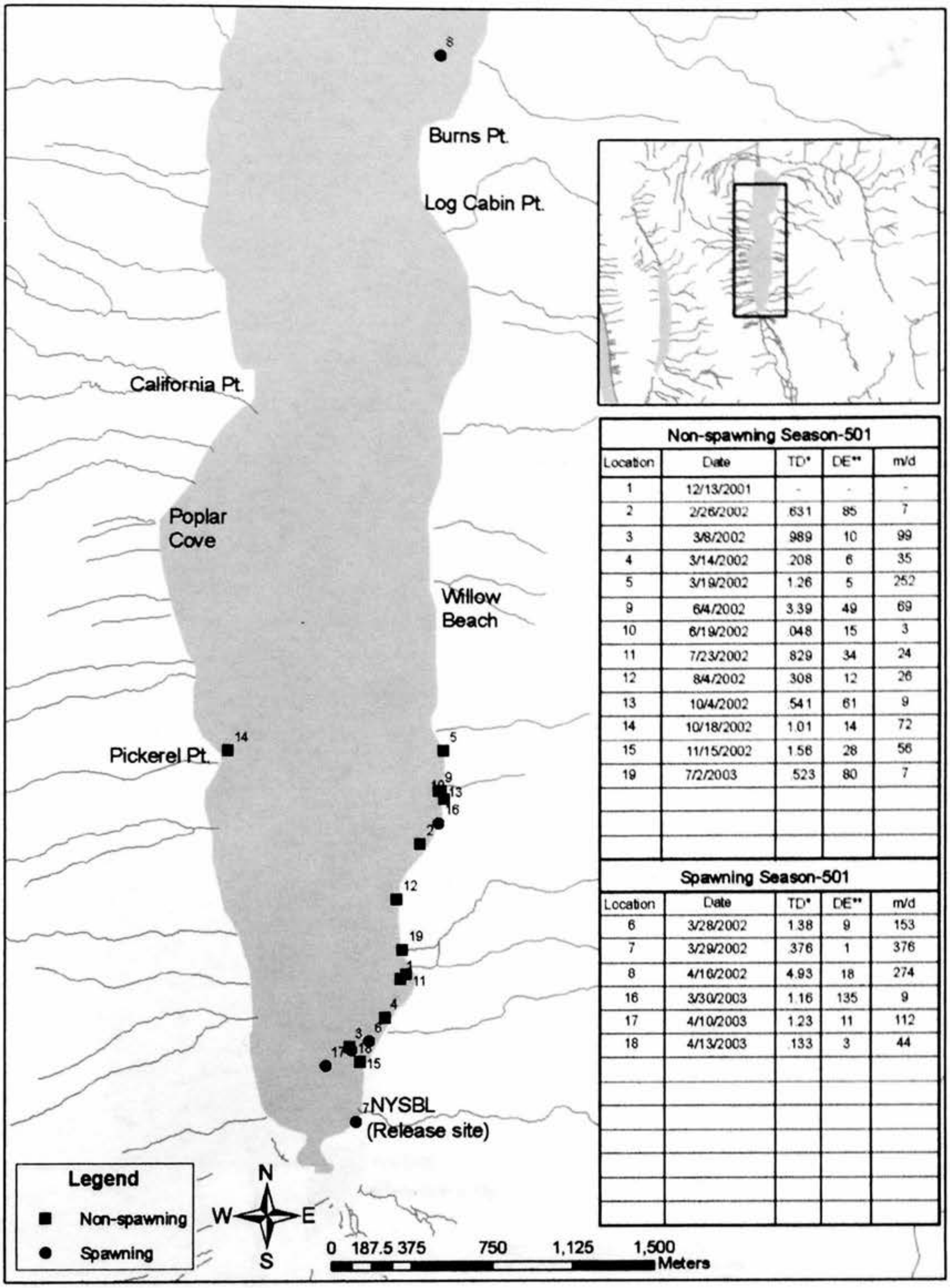
Non-spawning Season-341

Location	Date	TD*	DE**	m/d
1	12/13/2001	-	-	-
2	2/19/2002	.11	68	2
3	2/26/2002	1.04	7	149
4	3/8/2002	.742	10	74
5	3/19/2002	.85	11	77
12	6/4/2002	.327	49	7
13	6/19/2002	.317	15	21
14	7/23/2002	.154	34	5
15	8/4/2002	.264	12	22

Spawning Season-341

Location	Date	TD*	DE**	m/d
6	3/28/2002	.05	9	6
7	3/29/2002	.211	1	211
8	4/2/2002	.539	4	134
9	4/3/2002	.583	1	583
10	4/11/2002	1.03	8	129
11	4/16/2002	.105	5	21

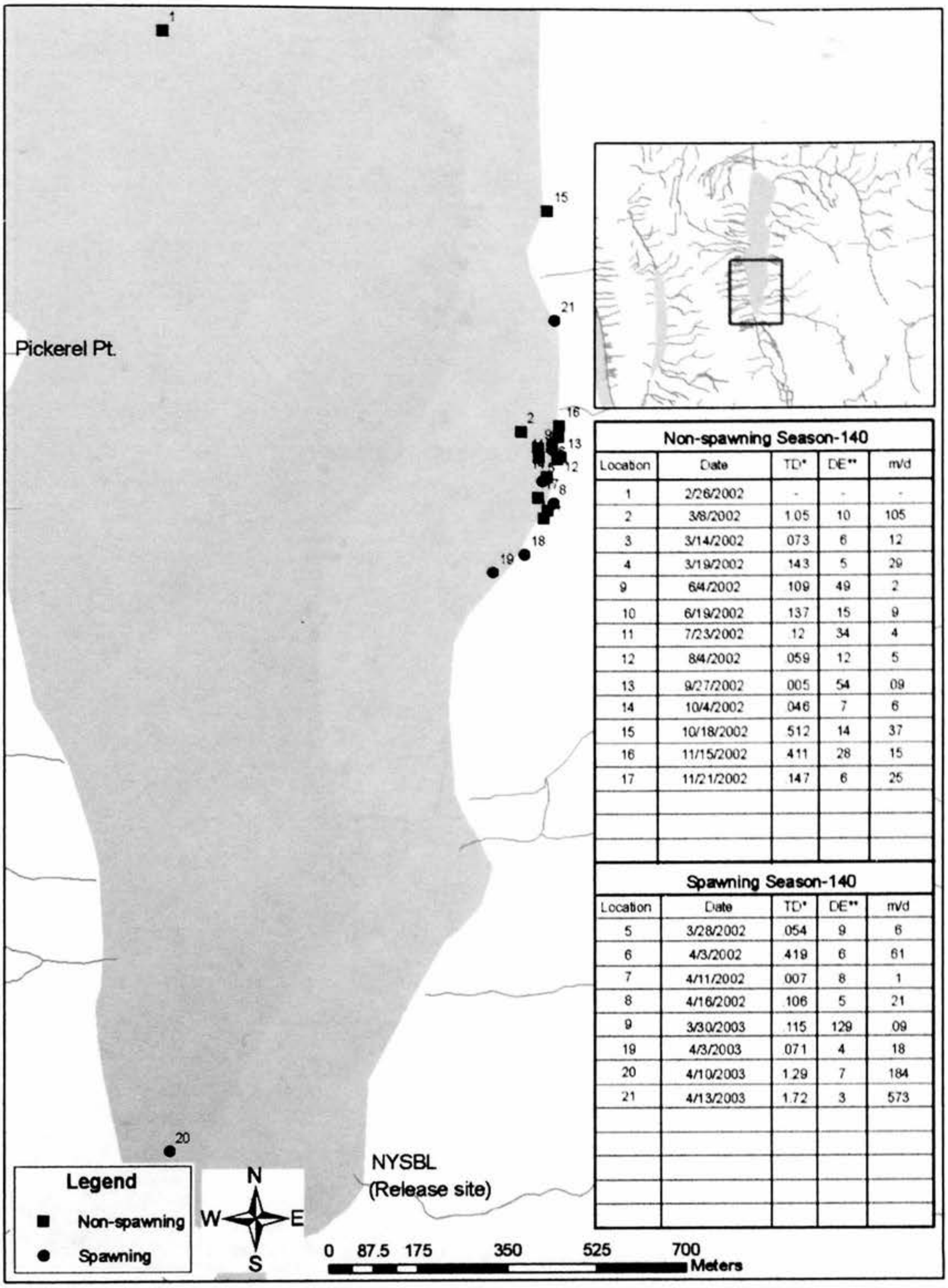
Appendix II.2 Fish 341



Non-spawning Season-501				
Location	Date	TD*	DE**	m/d
1	12/13/2001	-	-	-
2	2/26/2002	.631	85	7
3	3/8/2002	.989	10	99
4	3/14/2002	.208	6	35
5	3/19/2002	1.26	5	252
9	6/4/2002	3.39	49	69
10	6/19/2002	.048	15	3
11	7/23/2002	.829	34	24
12	8/4/2002	.308	12	26
13	10/4/2002	.541	61	9
14	10/18/2002	1.01	14	72
15	11/15/2002	1.56	28	56
19	7/2/2003	.523	80	7

Spawning Season-501				
Location	Date	TD*	DE**	m/d
6	3/28/2002	1.38	9	153
7	3/29/2002	.376	1	376
8	4/16/2002	4.93	18	274
16	3/30/2003	1.16	135	9
17	4/10/2003	1.23	11	112
18	4/13/2003	.133	3	44

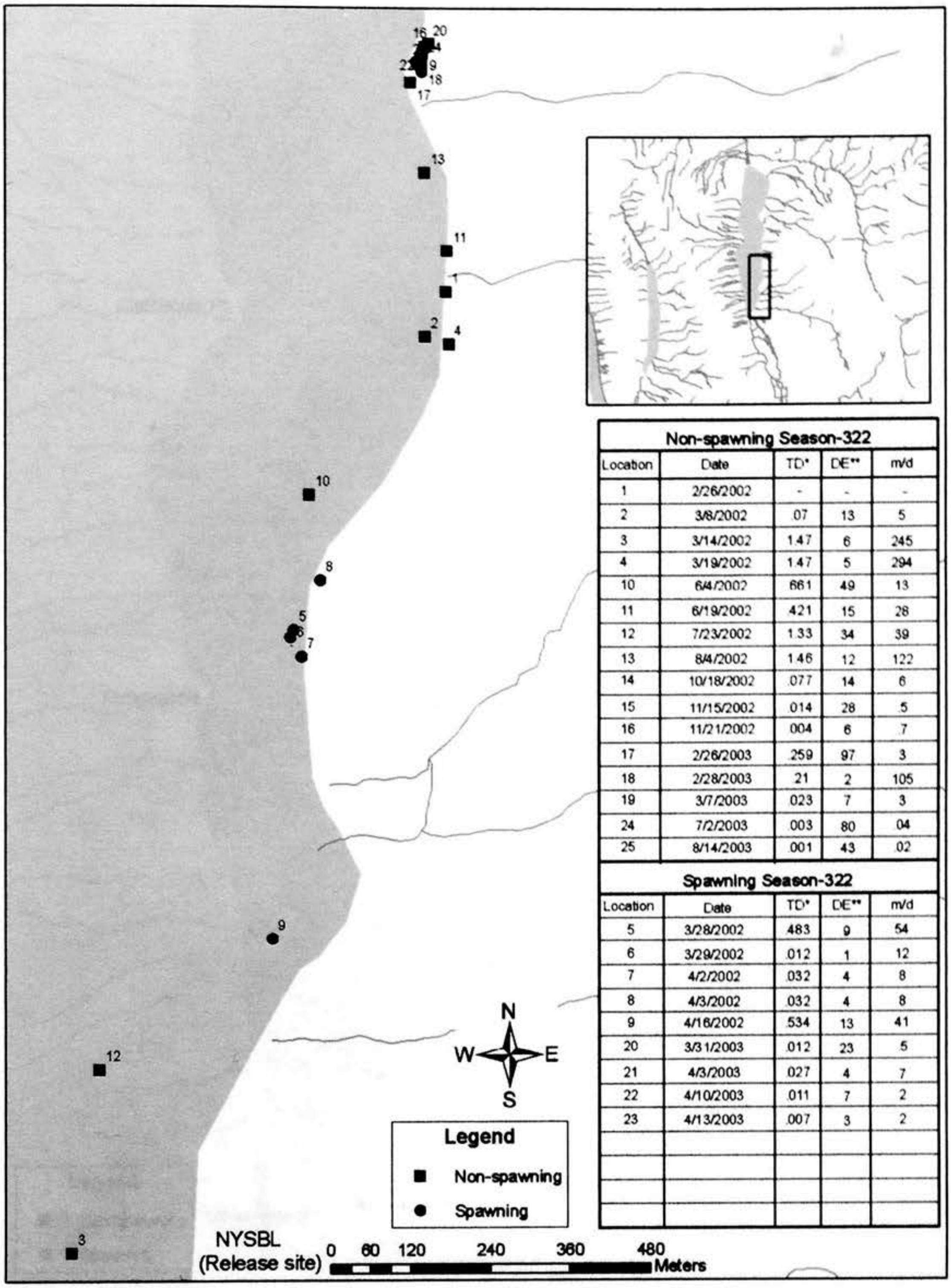
Appendix II.3 Fish 501



Non-spawning Season-140				
Location	Date	TD*	DE**	m/d
1	2/26/2002	-	-	-
2	3/8/2002	1.05	10	105
3	3/14/2002	073	6	12
4	3/19/2002	143	5	29
9	6/4/2002	109	49	2
10	6/19/2002	137	15	9
11	7/23/2002	.12	34	4
12	8/4/2002	059	12	5
13	9/27/2002	005	54	09
14	10/4/2002	046	7	6
15	10/18/2002	512	14	37
16	11/15/2002	411	28	15
17	11/21/2002	.147	6	25

Spawning Season-140				
Location	Date	TD*	DE**	m/d
5	3/28/2002	.054	9	6
6	4/3/2002	.419	6	61
7	4/11/2002	007	8	1
8	4/16/2002	.106	5	21
9	3/30/2003	.115	129	.09
19	4/3/2003	.071	4	18
20	4/10/2003	1.29	7	184
21	4/13/2003	1.72	3	573

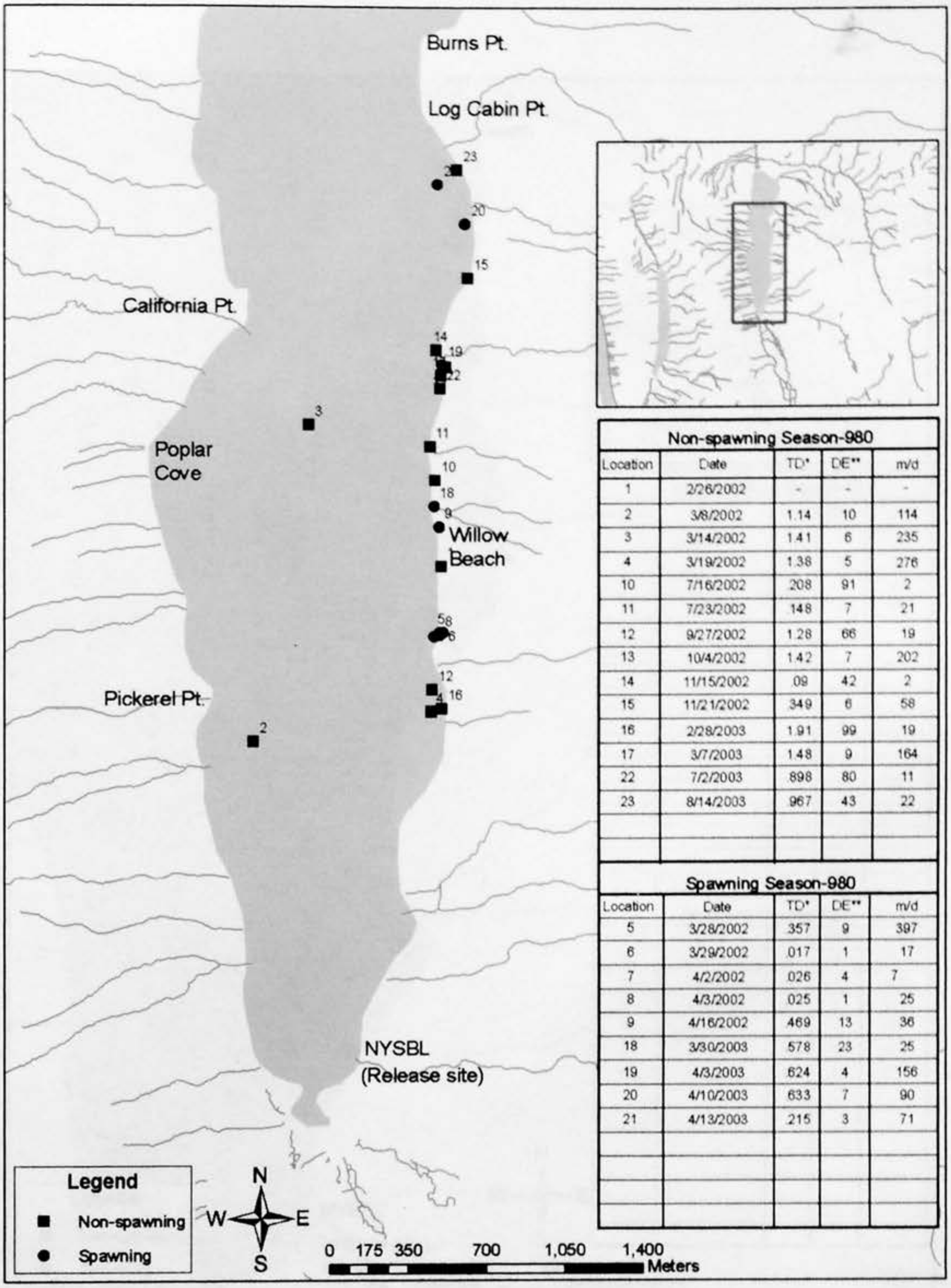
Appendix II.4 Fish 140



Non-spawning Season-322				
Location	Date	TD*	DE**	m/d
1	2/26/2002	-	-	-
2	3/8/2002	.07	13	5
3	3/14/2002	1.47	6	245
4	3/19/2002	1.47	5	294
10	6/4/2002	661	49	13
11	6/19/2002	.421	15	28
12	7/23/2002	1.33	34	39
13	8/4/2002	1.46	12	122
14	10/18/2002	.077	14	6
15	11/15/2002	.014	28	.5
16	11/21/2002	.004	6	.7
17	2/26/2003	.259	97	3
18	2/28/2003	.21	2	105
19	3/7/2003	.023	7	3
24	7/2/2003	.003	80	.04
25	8/14/2003	.001	43	.02

Spawning Season-322				
Location	Date	TD*	DE**	m/d
5	3/28/2002	483	9	54
6	3/29/2002	.012	1	12
7	4/2/2002	.032	4	8
8	4/3/2002	.032	4	8
9	4/16/2002	.534	13	41
20	3/31/2003	.012	23	.5
21	4/3/2003	.027	4	7
22	4/10/2003	.011	7	2
23	4/13/2003	.007	3	2

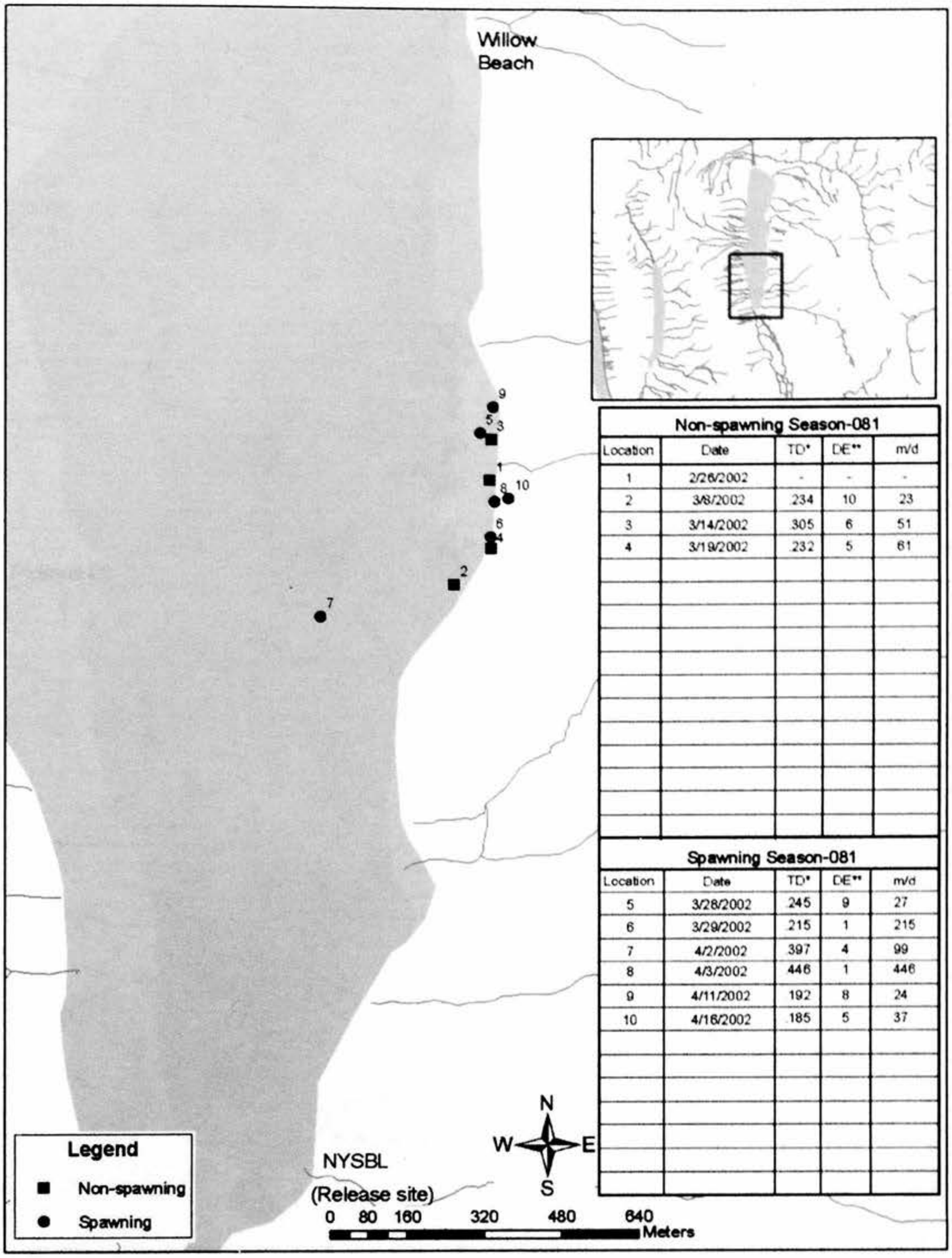
Appendix II.5 Fish 322



Non-spawning Season-980				
Location	Date	TD*	DE**	m/d
1	2/26/2002	-	-	-
2	3/8/2002	1.14	10	114
3	3/14/2002	1.41	6	235
4	3/19/2002	1.38	5	276
10	7/16/2002	.208	91	2
11	7/23/2002	.148	7	21
12	9/27/2002	1.28	66	19
13	10/4/2002	1.42	7	202
14	11/15/2002	.09	42	2
15	11/21/2002	.349	6	58
16	2/28/2003	1.91	99	19
17	3/7/2003	1.48	9	164
22	7/2/2003	.898	80	11
23	8/14/2003	.967	43	22

Spawning Season-980				
Location	Date	TD*	DE**	m/d
5	3/28/2002	.357	9	397
6	3/29/2002	.017	1	17
7	4/2/2002	.026	4	7
8	4/3/2002	.025	1	25
9	4/16/2002	.469	13	36
18	3/30/2003	.578	23	25
19	4/3/2003	.624	4	156
20	4/10/2003	.633	7	90
21	4/13/2003	.215	3	71

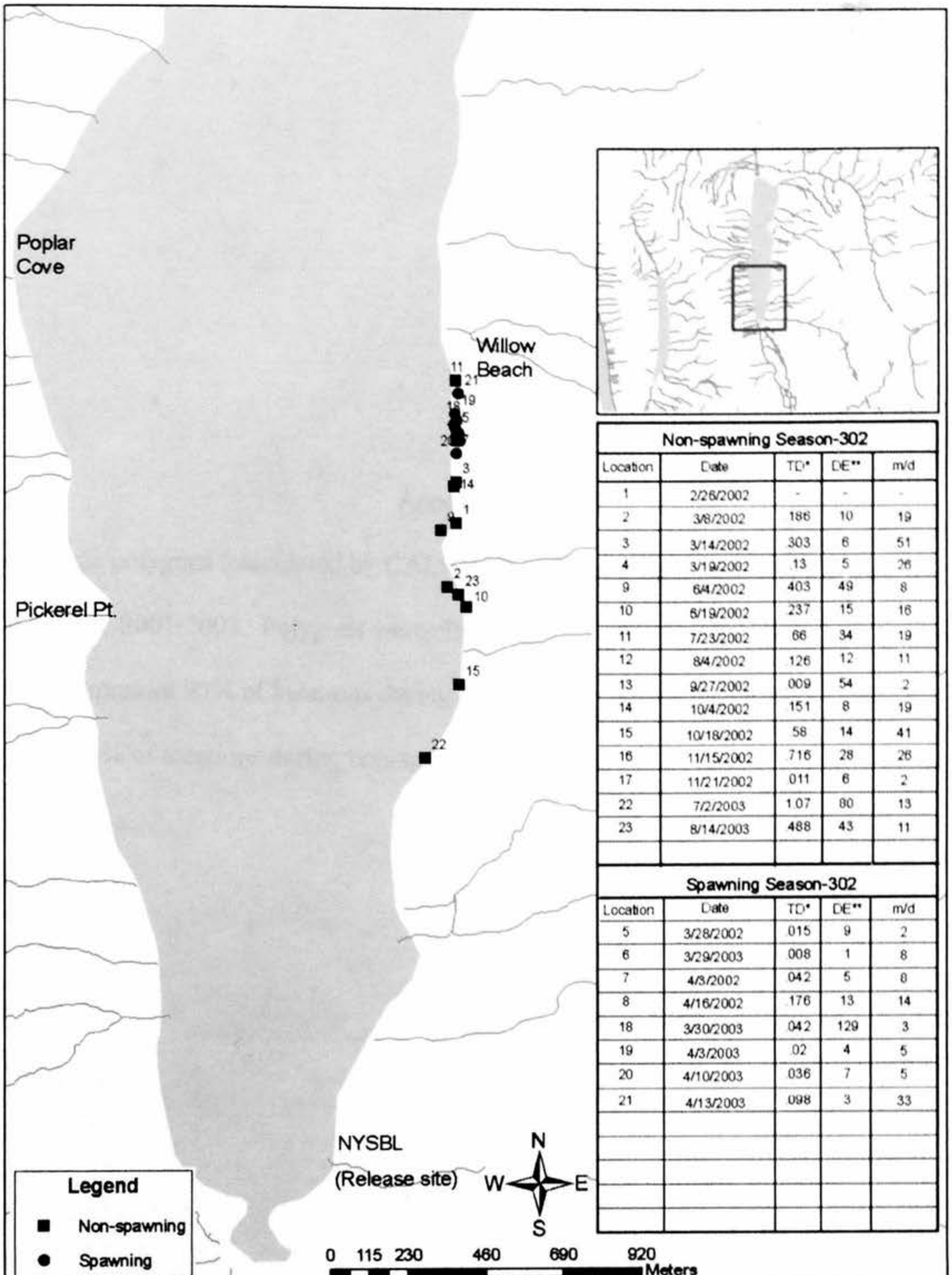
Appendix II.6 Fish 980



Non-spawning Season-081				
Location	Date	TD*	DE**	m/d
1	2/26/2002	-	-	-
2	3/8/2002	234	10	23
3	3/14/2002	305	6	51
4	3/19/2002	232	5	61

Spawning Season-081				
Location	Date	TD*	DE**	m/d
5	3/28/2002	245	9	27
6	3/29/2002	215	1	215
7	4/2/2002	397	4	99
8	4/3/2002	446	1	446
9	4/11/2002	192	8	24
10	4/16/2002	185	5	37

Appendix II.7 Fish 081



Non-spawning Season-302				
Location	Date	TD*	DE**	m/d
1	2/26/2002	-	-	-
2	3/8/2002	186	10	19
3	3/14/2002	303	6	51
4	3/19/2002	.13	5	26
9	6/4/2002	403	49	8
10	6/19/2002	237	15	16
11	7/23/2002	66	34	19
12	8/4/2002	.126	12	11
13	9/27/2002	009	54	2
14	10/4/2002	151	8	19
15	10/18/2002	58	14	41
16	11/15/2002	716	28	26
17	11/21/2002	011	6	2
22	7/2/2003	1.07	80	13
23	8/14/2003	488	43	11

Spawning Season-302				
Location	Date	TD*	DE**	m/d
5	3/28/2002	015	9	2
6	3/29/2003	008	1	8
7	4/3/2002	042	5	8
8	4/16/2002	.176	13	14
18	3/30/2003	042	129	3
19	4/3/2003	.02	4	5
20	4/10/2003	036	7	5
21	4/13/2003	098	3	33

Appendix II.8 Fish 302

Appendix III

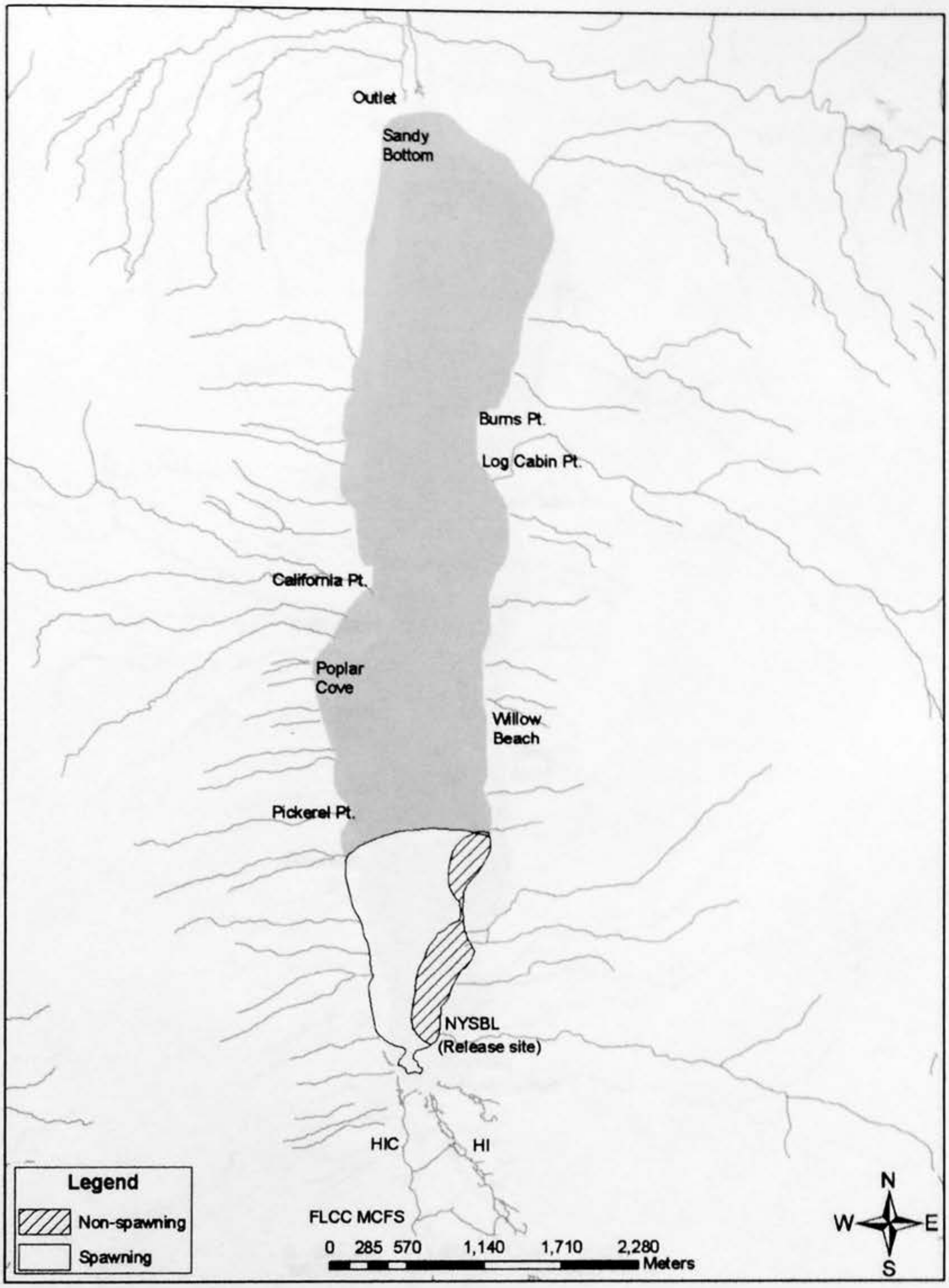
Home range polygons (calculated by CALHOME software) for walleye in the Honeoye Lake system, 2001-2003. Polygons were clipped to correspond to the shoreline. Hollow polygons represent 95% of locations during the spawning season and filled polygons represent 95% of locations during non-spawning seasons.

III.1 Fish 501

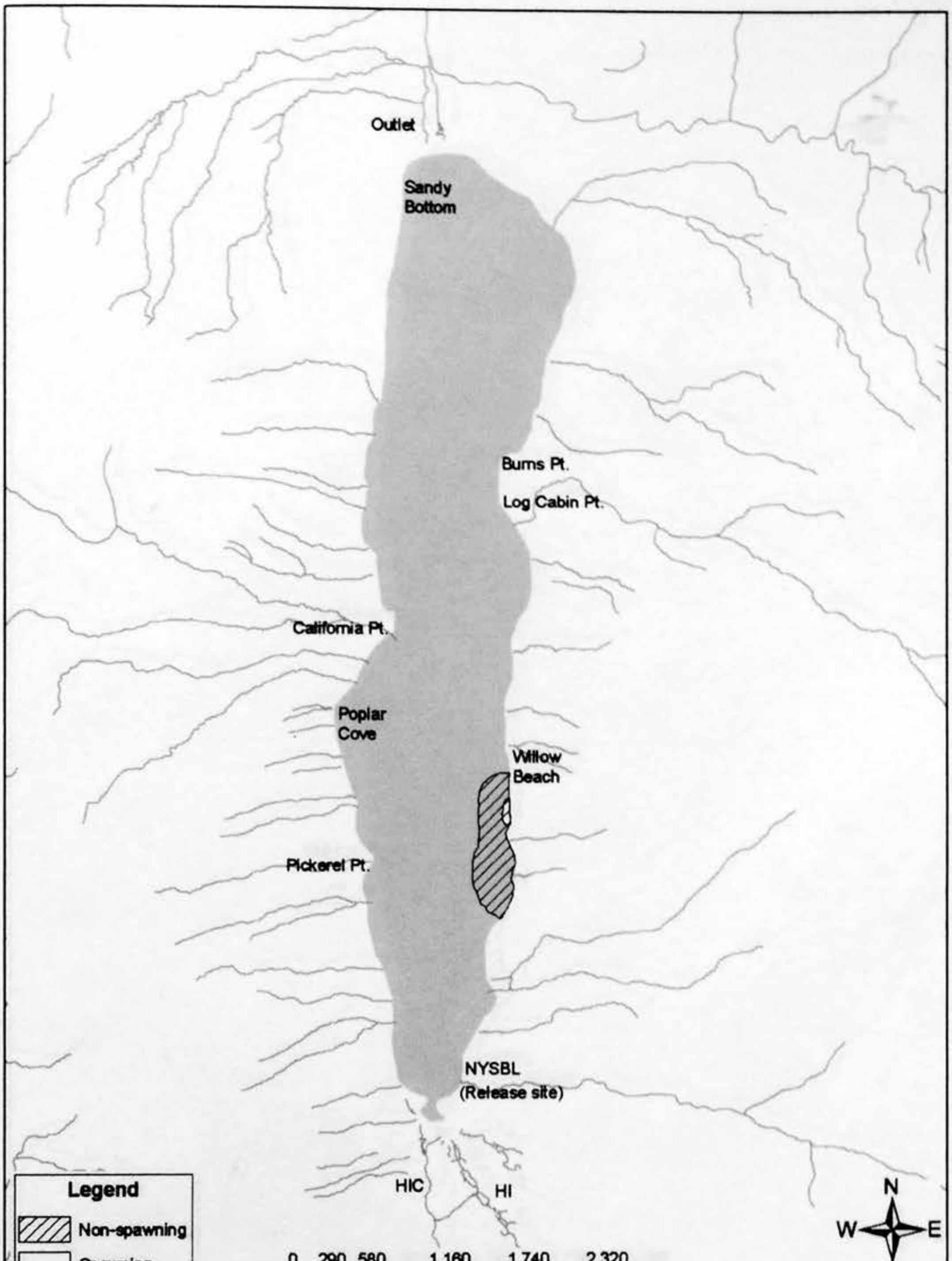
III.2 Fish 302

III.3 Fish 341

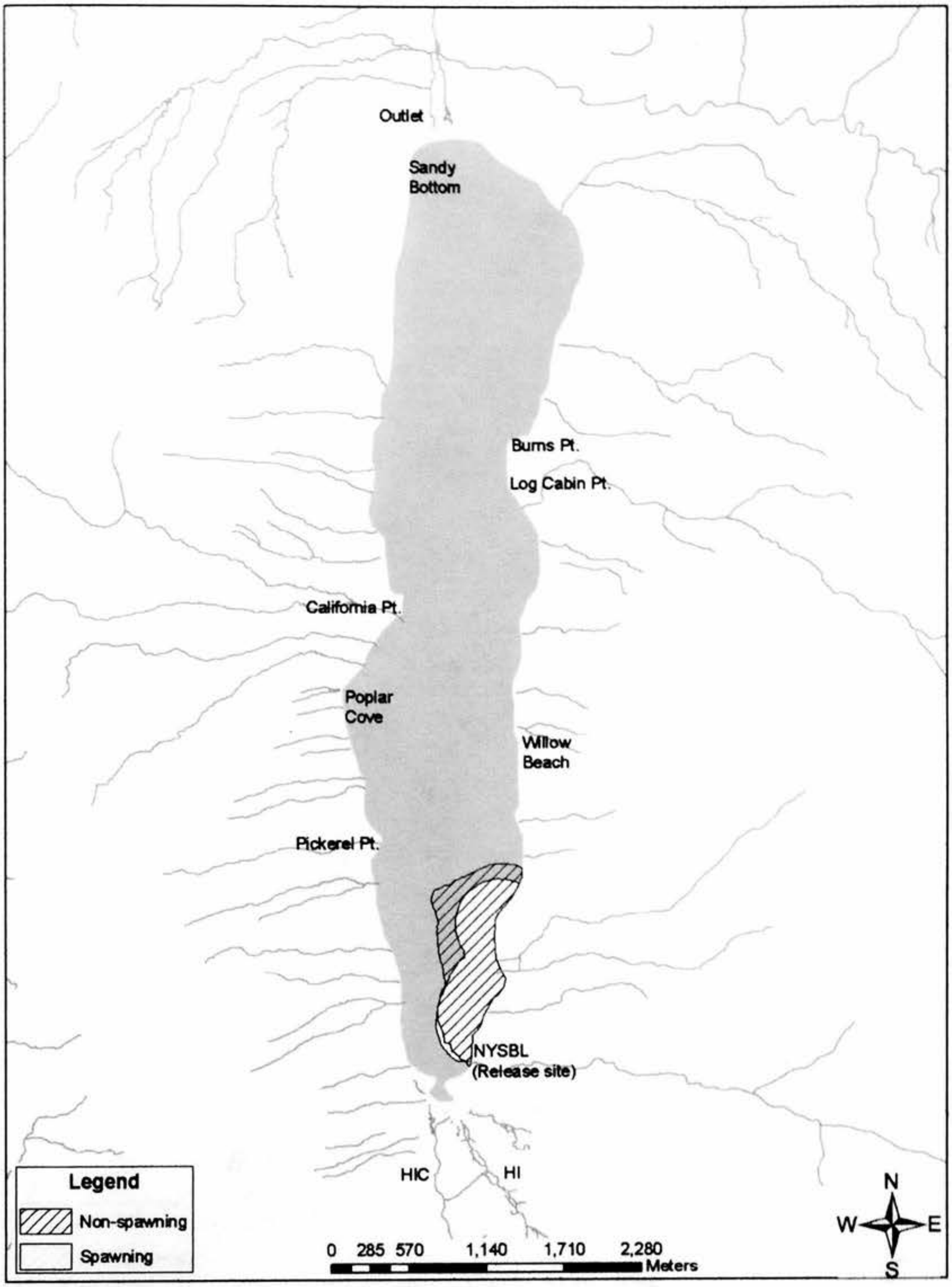
III.4 Fish 980



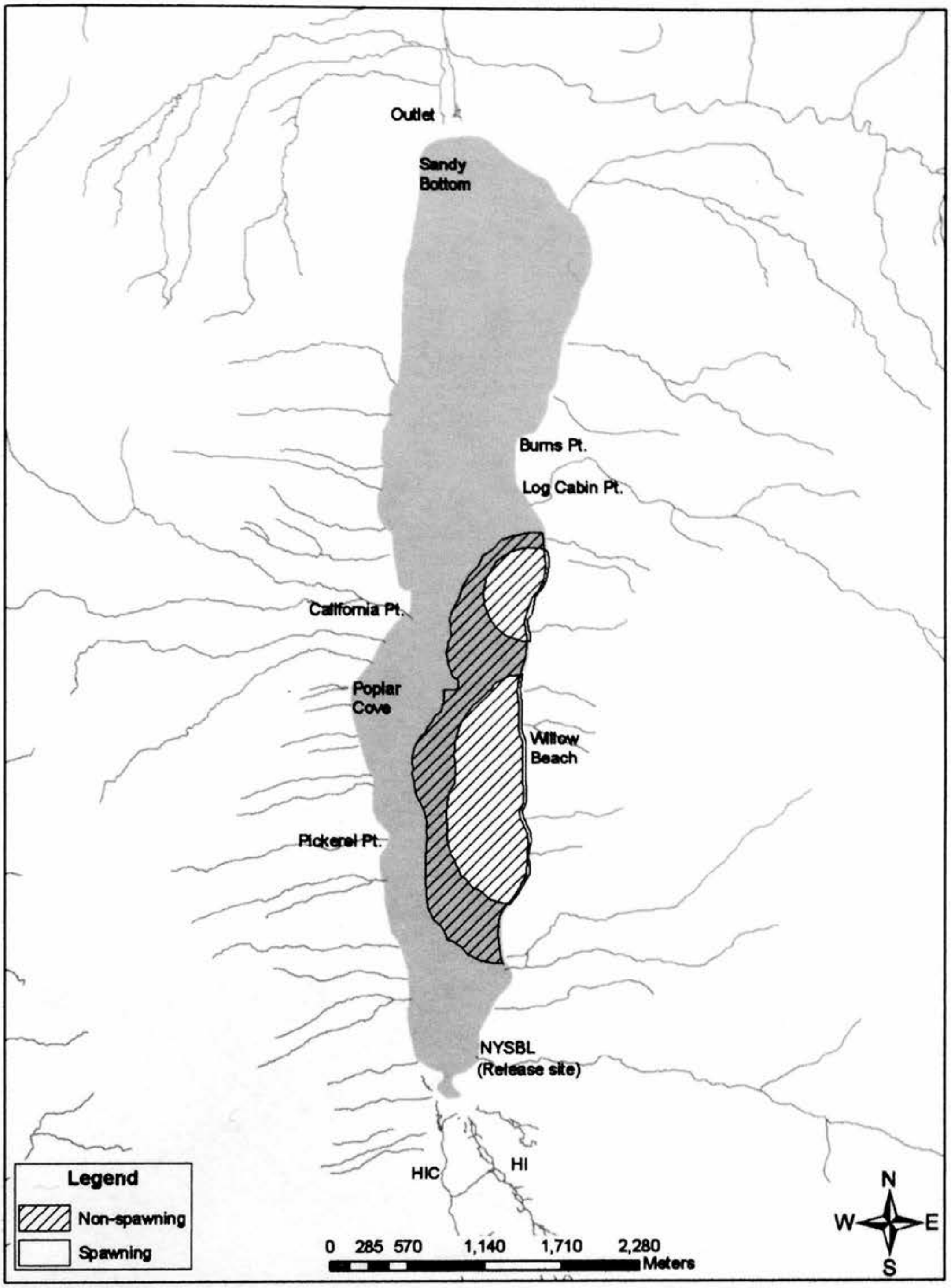
Appendix III.1 Fish 501



Appendix III.2 Fish 302



Appendix III.3 Fish 341



Appendix III.4 Fish 980